

PAPERS AND PROCEEDINGS OF

THE

ROYAL

SOCIETY

OF TASMANIA

Edited by M. R. Banks and S. J. Smith

and Published by the Society

Hobart

Tasmania

31 OCTOBER 1992

VOLUME 126

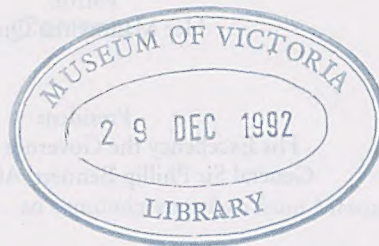


MUSEUM OF VICTORIA



08114





PAPERS AND PROCEEDINGS OF  
THE  
ROYAL  
SOCIETY  
OF TASMANIA



Edited by M. R. Banks and S. J. Smith

and Published by the Society

Hobart

Tasmania

Government Printer

31 OCTOBER 1992

Tasmania

VOLUME 126

ISSN 0080-4703

## COUNCIL AND OFFICE BEARERS

Patron  
Her Majesty the Queen

President  
His Excellency the Governor of Tasmania  
General Sir Phillip Bennett, AC, KBE, DSO

Vice-Presidents  
Professor D.M. Stoddart      Dr A.V. Brown

Council

|                  |                     |
|------------------|---------------------|
| Mr J.T.W. Hayton | Dr E.V.R. Ratcliffe |
| Mr R. Kerrison   | Dr J.S. Rogers      |
| Mrs G. Lord      | Mr P.C. Stevenson   |
| Mr A.T. Orr      | Mr C.B. Tassell     |
| Dr P.G. Quilty   | Dr V. von Witt      |

Honorary Secretary  
Mr D.R. Gregg

Honorary Treasurer  
Mr T.A.H. Knight

Honorary Auditor  
Mr T.O. Bayley FCA

Honorary Editor  
Dr M.R. Banks AM

Assistant Honorary Editor  
Dr S.J. Smith

# PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

## VOLUME 126

### Contents

|                                                                                                                                                                              | <i>page</i> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Annual report                                                                                                                                                                | iv          |
| TIDWELL, W.D. — <i>Millerocaulis richmondii</i> sp. nov., an osmundaceous fern from Mesozoic strata near Little Swanport, Tasmania, Australia                                | 1           |
| RICKARDS, R.B. & BANKS, M.R. — Two <i>Monograptus</i> species from the Prídolí of western Tasmania                                                                           | 9           |
| DIXON, G. — Notes on the geology, geomorphology and soils of the Algonkian Rivulet—upper Maxwell River area, Tasmanian Wilderness World Heritage Area                        | 13          |
| BAILLIE P.W. & SUTHERLAND, F.L. — Devonian lamprophyres from Mt Lyell, western Tasmania                                                                                      | 19          |
| PONDER, W.F. — A new genus and species of aquatic cave-living snail from Tasmania (Mollusca: Gastropoda: Hydrobiidae)                                                        | 23          |
| NEW, T.R. — The lacewings (Insecta, Neuroptera) of Tasmania                                                                                                                  | 29          |
| KIERNAN, K. — Mountain geomorphology and the Last Glaciation at Lake St Clair                                                                                                | 47          |
| JAGO, J.B. & BROWN, A.V. — Early Idamean (Late Cambrian) agnostoid trilobites from the Huskisson River, Tasmania                                                             | 59          |
| HORWITZ, P. & BLAKE, G. — The benthic macrofauna of sludge-affected sediments in the Derwent Estuary, southern Tasmania                                                      | 67          |
| CLARKE, M.J. — A new notospiriferine genus (Spiriferida: Brachiopoda) from the Permian of Tasmania                                                                           | 73          |
| McQUILLAN, P.B. — A checklist of the Tasmanian tortricid moths (Lepidoptera: Tortricidae) and their host-plant relationships                                                 | 77          |
| HAMR, P. — A revision of the Tasmanian freshwater crayfish genus <i>Astacopsis</i> Huxley (Decapoda: Parastacidae)                                                           | 91          |
| RODGERS, K.A. — The laser Raman identity of gibbsite pseudomorphous after crocoite from Dundas, Tasmania                                                                     | 95          |
| HORWITZ, P. & ANDREW, J. — The conservation status of freshwater macro-invertebrates in the Buckland Military Training Area, southeastern Tasmania                           | 101         |
| ANDREWS, A.P. — A descriptive catalogue of the type material (Chordates) in the Tasmanian Museum                                                                             | 109         |
| GARRETT, M. & KANTVILAS, G. — Morphology, ecology and distribution of <i>Isoetes</i> L. in Tasmania                                                                          | 115         |
| ALBRECHT, D.E. — <i>Pratia platycalyx</i> is a synonym of <i>P. irrigua</i> (Campanulaceae: Lobelioideae)                                                                    | 123         |
| EDGAR, G.J. & CRESSWELL, G.R. — Seasonal changes in the hydrology and the distribution of plankton in the Bathurst Harbour estuary, southwestern Tasmania, 1988–89 — erratum | 125         |

#### *Acknowledgement*

*The Society acknowledges, with thanks, grants towards the cost of publication from the State Government of Tasmania and from the University of Tasmania.*

## ROYAL SOCIETY OF TASMANIA

### Annual Report for the year 1991

The Council has the honour to present to members the following report on the activities of the Society during the year.

#### Council and Office Bearers

Patron  
Her Majesty the Queen

President  
His Excellency the Governor of Tasmania  
General Sir Phillip Bennett, AC, KBE, DSO

Vice-Presidents  
Professor D.M. Stoddart  
Dr A.V. Brown

| Council          |                     |
|------------------|---------------------|
| Mr J.T.W. Hayton | Dr E.V.R. Ratcliffe |
| Mr R. Kerrison   | Dr J.S. Rogers      |
| Mrs G. Lord      | Mr P.C. Stevenson   |
| Mr A.T. Orr      | Mr C.B. Tassell     |
| Dr P.G. Quilty   | Dr V. von Witt      |

Honorary Secretary  
Mr D.R. Gregg

Honorary Treasurer  
Mr T.A.H. Knight

Honorary Auditor  
Mr T.O. Bayley FCA

Honorary Editor  
Dr M.R. Banks AM

Assistant Honorary Editor  
Dr S.J. Smith

#### President

His Excellency General Sir Phillip Bennet took the chair as President of the Society at the Annual General Meeting. He also launched *Aspects of Tasmanian Botany — a Tribute to Winifred Curtis* at the Tasmanian Museum and Art Gallery on 16 April. In August he addressed a joint meeting of the Northern Branch and the Launceston Historical society.

#### Deaths

The deaths of the following members are recorded with regret:

Mr G. Anderson  
Mr P.A. Canning  
Mr R.M. Gunn  
Mr M.C.B. Hills  
Dr J.H.B. Walch

#### Professor David Headley Green FRS

The Council congratulates Professor D.H. Green, PhD, DSc, FAA, Hon FGSA, FRS, of the Department of Geology, University of Tasmania, on his election as a Fellow of the Royal Society (London). In 1991 he was appointed Chief Science Adviser to the Minister for Arts, Sport, the Environment, Tourism and Territories. Professor Green has been a member of the Royal Society of Tasmania since 1956.

#### G. Hawley Stancombe OAM

Mr G. Hawley Stancombe was awarded a Medal of the Order of Australia in the Australia Day honours list. He has been a member of the Society since 1948.

#### Honorary Life member

Mr T.A.H. Knight was elected an Honorary Life Member of the Society at the General Meeting on 1 October. This was in recognition of his services as Honorary Treasurer since 1978. Mr Knight joins six other Honorary Life Members:

Dr William Bryden, CBE  
Mr Frank Ellis, OBE  
Mr Gordon Hale  
Dr Maxwell Banks, AM  
Mr Don Gregg  
Mr Peter Webb

#### Annual Meeting

At the Annual Meeting on 5 March, Dr J.S. Rogers retired as Vice-President and Mr P.M. Bennison and Professor D.M. Stoddart as Members of the Council. The following were elected:

|                    |                                     |
|--------------------|-------------------------------------|
| Vice Presidents    | Prof D.M. Stoddart, Dr A.V. Brown   |
| Members of Council | Mr J.T.W. Hayton, Mr P.C. Stevenson |
| Honorary Secretary | Mr D.R. Gregg                       |
| Honorary Treasurer | Mr T.A.H. Knight                    |
| Honorary Auditor   | Mr R.J. Dwyer                       |

## Membership

The membership is 422, a decrease of 31, and is made up as follows:

|                                                                 | Northern Branch | Total     |
|-----------------------------------------------------------------|-----------------|-----------|
| Honorary Life Members                                           | 2               | 8         |
| Life Members                                                    | 11              | 35        |
| Ordinary Members receiving<br><i>Papers and Proceedings</i>     | 58              | 257       |
| Ordinary Members not receiving<br><i>Papers and Proceedings</i> | 46              | 103       |
| Associate Members                                               | <u>11</u>       | <u>19</u> |
|                                                                 | 128             | 422       |

## Council Meetings

The Council met four times during the year.

## Royal Society Lecture Series

At the initiative of Dr J.S. Rogers a series of public lectures was proposed to start in July. There was an excellent response from potential lecturers but there were problems with the promotion of the lectures through the media.

The proposed lectures were cancelled due to lack of response from the public.

## Sesquicentennial of the Society

The Society will be 150 years old in 1993 and the sesquicentennial will be marked by the publication of an 1887 manuscript from the Society's archives by James Backhouse Walker describing an expedition to the West Coast of Tasmania.

## Future Directions for Australian Science: A Tasmanian Perspective

A symposium was organised by the Tasmanian Division of ANZAAS and the Royal Society of Tasmania at the CSIRO Marine Laboratories, Hobart, on 6–7 September. The symposium was supported by CSIRO and the Menzies Centre for Population Health Research, University of Tasmania.

The symposium, attended by 64 people, was opened by the Premier of Tasmania, the Hon. Michael Field, MHA, and keynote speakers were Professor Ralph Slatyer, Chief Scientist, Department of Prime Minister and Cabinet, and Dr John Stocker, Chief Executive, CSIRO.

The papers and proceedings of the symposium were published in November.

## Grants to Society

The Council regretted that no general grant was received from the Tasmanian Government in the 1990–91 budget. However, a grant of \$2000 has been received through Arts Tasmania in 1991–92. This is welcome although less than the \$2500 grant in 1989–90. The \$3000 grant towards the printing of the *Papers and Proceedings* has continued at the same level.

The University of Tasmania has provided an annual subvention of \$3000 towards the *Papers and Proceedings*.

## Library

The year was marked by staffing changes with the transfer of Mrs Beth Chalmers to another position within the University Library and the appointment of Mr Graeme Rayner to the previously vacant position of Special Collections Librarian of which the activities of the Royal Society Librarian form a substantial part. The level of clerical assistance was effectively maintained throughout the year with Mrs Carol Freeman working part time within the Royal Society Library area.

During the year 287 copies of the Society's *Papers and Proceedings* (Vol. 124) were sent out to exchange partners, together with a flyer giving details of 'Aspects of Tasmanian Botany' which is available for purchase. During the year 142 serial volumes were bound.

A weeding project designed to identify outdated and superseded monographs was begun during the year and a large number of such titles has been collected for consideration. Separate reports are being prepared on the eventual disposal of such items. It is hoped that a similar review of the serial titles will identify those of a similar status, and thus candidates for disposal.

Improvements were made to the storage conditions in both the closed access and Rare Books room with the installation of black-out holland blinds. These blinds provide a dark and cooler atmosphere for the storage of the valuable materials held in these areas.

During the year arrangements were made for the removal of excess stock of Royal Society publications formerly held in the University Library basement. The volumes were either transferred to the care of the Society, or in the case of the Wedge diaries, sold for the benefit of the Society.

The small monograph cataloguing backlog was reviewed during the year and arrangements are in hand to produce card sets from the University Library database for those titles also held within the Library's collection; almost a third of the titles awaiting cataloguing fall into this category. Integration of the Royal Society Library's holdings into the University Library's database remains a possibility and is still awaiting further costing and consideration.

The maintenance of statistics for use of the Library remains something of a problem; there is no assurance that visitors actually sign the record books provided. Two books are maintained, one providing details of visitors and the other a record of items consulted (but not borrowed). Statistics of recorded information for 1991 is provided, but actual usage may be higher.

|                        |     |
|------------------------|-----|
| Visitors               | 354 |
| Serial Loans           | 69  |
| Inter-Library Loans    | 40  |
| In-house consultations | 84  |

## Publications

Two volumes were published in 1991, *Aspects of Tasmanian Botany — a tribute to Winifred Curtison* on 8 April, and *Papers and Proceedings*, Volume 125, on 20 December.

*Aspects of Tasmanian Botany*, consisting of a biography and 27 other papers by 36 authors, totalled 247 pages. It was launched by the President, His Excellency General Sir Phillip Bennett on 16 April. The volume has been well received and is selling satisfactorily. It had been planned to issue *Aspects* as Volume 124, Part 2 of the *Papers and Proceedings*. However, the response to invitations to publish in *Aspects* exceeded expectations. In view of this response and uncertainty as to available funds it was published as a special publication thus meeting the need originally intended to be met

by Part 2 of Volume 124. Under these circumstances it was decided to publish the next volume of *Papers and Proceedings* in the standard system and number it Volume 125.

Volume 125 contained, in addition to the Annual Report for 1990, twelve papers and two brief errata; papers and errata totalling 79 pages. For financial reasons, Volume 125 was published in a double column A4 format and it is planned to use this format into the foreseeable future. Towards the end of the year, Council instituted a system of page charges for papers of length greater than ten printed pages.

Work has continued on editing of papers delivered at the World Heritage Area Symposium in November 1990 but was slower than hoped because of the absence overseas on a Churchill Fellowship of the volume editor, Dr S. J. Smith. Publication in the first half of 1992 is planned.

Publication of *Aspects* was aided considerably by generous donations from many individuals and institutions. Publication of Volume 125 was assisted greatly by grants from the Tasmanian Government and the University of Tasmania. The publications owe much of their quality to the sub-editing of Mrs Alison Jones and the type-setting and formatting by Mrs June Pongratz.

The Society is once more indebted to Dr Banks and Dr Smith for their dedicated editorial work.

## Lectures

The following lectures were given at General Meetings during the year:

March — "Delivering medical care in the Pacific Basin" Dr J.S. Rogers, retiring Vice-President.

April — "High energy particles from the Sun" Dr Hilary Cane, University of Tasmania and NASA/Goddard Space Flight Center.

May — "Value added library collections" (and an inspection of the University of Tasmania Library and the Royal Society Library) Mrs Christine Crocker, Librarian, University of Tasmania.

June — "The story of sharks as told by their teeth — true or false?" Mr N.R. Kemp, Tasmanian Museum and Art Gallery.

July — "Antarctic krill — from whale food to fishburgers" Dr Stephen Nicol, Antarctic Division.

August — "The genesis of Tasmanian mineral deposits" Dr Ross Large, Key Centre for Ore Deposit and Exploration Studies, University of Tasmania.

September — "A new look at some of Hobart's buildings" Mr Martin Davies, Department of Parks, Wildlife and Heritage.

October — "The role and future of the Society" Prof. D.M. Stoddart, Dr J.S. Rogers, Dr M.R. Banks, Mr D.R. Gregg, and Dr A.V. Brown.

November — "Micronutrients and antioxidants and the aging process" Dr Ivor Dreosti, Division of Human Nutrition, CSIRO, Adelaide.

The May meeting was held at the University of Tasmania Library.

## Northern Branch

### Branch Council:

|                    |                                                                       |
|--------------------|-----------------------------------------------------------------------|
| Chairman           | Mr A. T. Orr                                                          |
| Vice-Chairman      | Dr E. V. R. Ratcliff                                                  |
| Honorary Secretary | Mr C. B. Tassell                                                      |
| Honorary Treasurer | Mr B. A. Pike                                                         |
| Honorary Members   | Mr B. Chamberlain, Mr J. Kolkert<br>Mr W. H. Stephens, Mrs M. Cameron |

The Branch Council met four times during the year.

The following lectures were given at General Meetings:

March — Special meeting on the future of the Royal Society of Tasmania Northern Branch.

April — "Education of civilised adults" Mr R. Walden

June — "The effects of the ultra violet rays on the skin" Dr D. Tilsley.

August — "Government Houses" (combined meeting with Launceston Historical Society) His Excellency, General Sir Phillip Bennett, Governor of Tasmania.

October — "Antarctic and global warming" Dr P.G. Quilty.

November — "The dinosaurs of darkness" (combined meeting with the Friends of the Queen Victoria Museum) Dr P. Vickers-Rich.

December — Members Night

"Origin of the names of elements" Mr W.H. Stephens

"Tasmanian Main Line Railway" Mr B. Chamberlain.

At the special meeting held in March it was resolved by the Northern Branch that meetings would not be held every month but rather for eight months of the year.

### Excursion:

16 June Excursion to the 'Mountford' bush block re-afforestation

## Nominees to Other Bodies

The Council elected Dr P G Quilty and Professor D M Stoddart to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery. They report on the year's activities:

1991 was a year of major re-organisation and transition for the Tasmanian Museum and Art Gallery. Mr Don Gregg retired on 15 October after almost 20 years as Director. His replacement is to be Ms Patricia Sabine, who will take up her position on 3 February 1992. In the intervening period Dr Tony Orchard was appointed as Acting Director. Another staff member of long standing, Miss Alison Green, Curator of Invertebrate Zoology, also retired in October after 23 years of service.

The change of Director has coincided with plans to review the staff structure and directions of the Museum and Art Gallery, and this review will proceed during 1992. Coincidentally a buildings audit of the Macquarie/Davey Street site is being carried out by the Department of Construction for the Department of Education and the Arts.

The 1991 State Budget provided a grant for recurrent services of \$1 686 000 an increase of about 8.6% over the allocation in the 1990 budget. Of this 73% will be spent on salaries and related costs.

Only one change occurred in the composition of the Board of Trustees during the year. Mr A. R. Neilson retired as Royal Society of Tasmania nominee to the Board on 31 January 1991. He had been a Trustee since 1981 and served as Chairman from 1984 to 1987 and from mid-1990 until his retirement. Mr A. M. Blow was elected Chairman at the February meeting.

The Australian Biological Resources Study through its Environmental Resources Information Network (ERIN) approved a grant of \$47 294 to facilitate the entry of Herbarium label information into a computer data base. Dr Orchard received a grant of \$11 319 from the Australian Biological Resources Study for his continuing investigation of the genus *Cassinia*. Dr Kantvilas received a further National Estate grant (\$7250) towards his study of Tasmanian rainforest lichens.

The Visual Arts/Crafts Board of the Australia Council provided a grant to assist with sending the exhibition *Profiles* to Brisbane.

The Hobart City Council provided a grant of \$12 000 for the year.

The Trustees and senior staff met for the day on Saturday 13 April 1991 to discuss the future of the Tasmanian Museum and Art Gallery. As a result of the meeting five standing committees, made up of staff and Trustees, have been set up to consider publications, public relations, funding and finance, exhibition display and education, and buildings and gardens.

During 1991, a total of 99 517 people visited the Museum and Art Gallery compared with 110 486 in 1990.

The number of visitors to the West Coast Pioneers Memorial Museum remains static at about 98 000 for 1990–91.

A very successful exhibition, *Dinosaurs Alive*, was shown in the City Hall from 23 August to 29 September, attracting an attendance of 60 000 people.

Other temporary exhibitions shown included *Early 20th Century Images of Hobart and Tasmania* (January–February), *Reformers, Redeemers and Royal* (February–March), *John Coburn: The Seasons Tapestry Collection* (February–April), *The Art of Colonial Women* (March–April), *Profiles* (April–May), *Thomas Bock: Convict Engraver/Society Portraitist* (April–June), *Witnesses in the Anteroom to Hell* (June–July), *Roger Kemp: Etchings* (June–August), *Aboriginal Watercolours of Albert Namatjira and his Followers* (June–August), *Ellis Rowan 1848–1922: A Flower-Hunter in Queensland* (July–August), *Swiss Origins of Australian Art 1777–1991* (August–September), *Colonial Cabinetmakers* (September–October), *Moet and Chandon 1991* (October–November), *Propositions: from the Centre for Furniture Design* (November–December), *Printmakers in Tasmania* (November–January), *Animal Weeds* (December–May).

Mr J. E. Tomlinson A.O., was elected by the Council to serve on the Board of Trustees of the Royal Tasmanian Botanical Gardens. Mr Tomlinson reports on the Year's activities:

Despite budgetary problems common to all authorities, progress has been made during the year.

The Technical Support Centre has been completed and was opened by the Hon Harry Holgate, MHA, on 12 June. The new facilities are proving adequate and a vast improvement in working conditions.

A staff exchange program has been commenced with other Botanical Gardens and will be an ongoing part of the Gardens' activities. This has a double benefit — firstly the experience for the person going away, secondly, the contribution of the visiting exchange.

The Senses Garden, attached to the Easy Access Garden to enable visually impaired people to experience the fragrance and texture of

plants, has now been completed. Over 1000 people attended Horticultural Therapy classes.

The W.A.G. Walker Rhododendron Reserve was handed over to the Gardens on 29 November. This establishes a northern annexe to the Gardens and a very worthwhile addition to its activities. It is already a tourist attraction in the area and funds are being made available to further develop it over a period.

The Tulip Festival was held again on 29 September and was a great success, being attended by approximately 18 000 people. Plans are already being made for an even bigger event in 1992, when the 350th anniversary of Abel Tasman's first sighting of Tasmania will be celebrated.

The new irrigation system is being installed — much of the old piping being almost corroded through. A new fence to the lower car park has been commenced and will be a worthy addition.

The Tasmanian Native Plant Garden has been completed and is developing well. The Horse Chestnut (*Aesculus hippocastanum*) did not survive despite intensive efforts, and has now been removed.

Various activities have continued including:

The Education Officer has had groups of school children, Skill-share, gardening clubs, Probus, Rotary, etc. for talks, lectures and visits.

*January in the Gardens* which had garden walks, bird walks, slide shows, bus tours, craft classes and propagation classes for about 550 people.

Bus trips for over 1400 people from hospitals and nursing homes.

Friends of the Gardens has grown to over 150 members and would welcome further additions at \$30 for a family membership.

Early morning and evening plant and bird walks have been very popular.

During the calendar year 1991, 320 000 people visited the Royal Tasmanian Botanical Gardens.

## Acknowledgements

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and co-operation.

We are grateful for the dedicated help given by members of the Council during the year.

D.M. Stoddart  
Senior Vice-President

D.R. Gregg  
Honorary Secretary

11 February 1992

# ROYAL SOCIETY OF TASMANIA

## Statement of Receipts and Payments for the Year Ending 31 December 1991

| Balance sheet as at 31 December 1991 |         | General Account |                                      |
|--------------------------------------|---------|-----------------|--------------------------------------|
| 1990                                 | 1991    | 20 419.74       | Stationery                           |
| 60 192                               |         |                 | Postage                              |
| 530                                  |         |                 | Advertising                          |
|                                      |         |                 | Library books and subscriptions      |
|                                      |         |                 | Papers & proceedings                 |
| 2206                                 | 2250.49 | 8444.00         | Secretarial fees                     |
| 4719                                 | 4780.23 | 7426.74         | Post box rental                      |
| 2222                                 | 2270.24 | 2206.60         | Telephone                            |
| 846                                  | 868.54  | 103.33          | Bank duties/charges                  |
| 2323                                 | 2424.32 | 771.64          | Attendant fees                       |
| 3167                                 | 3233.37 | 2300.00         | Northern Branch                      |
| 1333                                 | 1332.64 | 2000.00         | Insurance                            |
| 3091                                 | 3113.51 | 3000.00         | Sundry                               |
| 6583                                 | 6605.55 | 440.00          | WHS expenses                         |
|                                      |         | 248.60          | RS room lighting                     |
|                                      |         |                 | Balance 31 December 1991             |
|                                      |         |                 | \$47 360.65                          |
|                                      |         |                 |                                      |
|                                      |         |                 | Accumulation Account                 |
|                                      |         |                 | Balance 1 January 1991               |
|                                      |         |                 | 60 192.28                            |
|                                      |         |                 |                                      |
|                                      |         |                 | Add                                  |
|                                      |         |                 | Increased cash at bank               |
|                                      |         |                 | 2082.70                              |
|                                      |         |                 | Net decrease in advance subscription |
|                                      |         |                 | 478.00                               |
|                                      |         |                 |                                      |
|                                      |         |                 | Deduct                               |
|                                      |         |                 | Decreased valuation of publications  |
|                                      |         |                 | 2664.42                              |
|                                      |         |                 | Net transfer to Trust Funds          |
|                                      |         |                 | 388.80                               |
|                                      |         |                 |                                      |
|                                      |         |                 | Balance 31 December 1991             |
|                                      |         |                 | \$59 699.76                          |

### Represented by:

|          |                                      |             |
|----------|--------------------------------------|-------------|
| 33       | Cash on hand                         | 33.00       |
|          | Cash at bank:                        |             |
| 20 420   | - General account                    | 22 276.53   |
| 4577     | - Papers and Proceedings account     | 4742.78     |
| 1038     | - Olive Lord Memorial Fund           | 1059.66     |
| 1452     | - A.N. Lewis Memorial Fund           | 1491.08     |
| 860      | Mortgage loan                        | 29 570.05   |
|          | Commonwealth Treasury Bonds and      | 860.00      |
|          | Inscribed Stock (at cost)            | 2000.00     |
| 2000     | Interest Bearing Deposits            | 7000.00     |
| 7000     | Library (at valuation for insurance) | 15 000.00   |
| 15 000   | Publications (at selling price)      | 26 567.60   |
| 29 232   | Medals (at selling price)            | 5600.00     |
| 5600     |                                      | \$86 630.65 |
| \$87 212 |                                      |             |

The Society owns works of art which have been donated over the years and which do not appear on the Balance Sheet. They are all housed in the Tasmanian Museum and Art Gallery and are covered by that organisation's insurance. A catalogue listing these works of art is available to members.

D.R. Gregg  
Honorary Secretary

T.A.H. Knight, BBus AASA  
Honorary Treasurer

## MILLEROCAULIS RICHMONDII SP. NOV., AN OSMUNDACEOUS FERN FROM MESOZOIC STRATA NEAR LITTLE SWANPORT, TASMANIA, AUSTRALIA

by William D. Tidwell

(with two text-figures, one table, and three plates)

TIDWELL, WILLIAM D., 1992 (31:x): *Millerocaulis richmondii* sp. nov., an osmundaceous fern from Mesozoic strata near Little Swanport, Tasmania, Australia. *Pap. Proc. R. Soc. Tasm.* 126: 1–7. ISSN 0080–4703. Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602, USA.

A permineralised rhizome from Mesozoic strata south of Little Swanport, Tasmania, represents a new species of *Millerocaulis* (*M. richmondii*). Its stem is  $6 \times 7$  mm across and is surrounded by adhering leaf bases with each having a stipular expansion typical of the Osmundaceae. The xylem of the ectophloic siphonostele comprising this stem is dissected by leaf gaps and consists of 14 xylem strands in its cylinder. Twenty leaf traces occur in a transverse section of its cortices. The xylem of its leaf traces and petiolar vascular strands is generally curved adaxially with a single protoxylem cluster being median on the trace. This protoxylem cluster bifurcates into two protoxylem groups immediately after leaving the stem and upon entering the petiole. The sclerotic ring of the petiole base is uniform in width and cell-wall thickness. A mass of sclerenchyma present in the adaxial concavity of the petiolar vascular strand expands at higher levels of the petiole until it fills the concavity of the strand and becomes immediately adjacent to the sclerotic ring. A large, round cellular mass of sclerenchyma occurs in the stipular expansions midway between their sclerotic rings and their tips. *Millerocaulis richmondii* is an additional species in the family Osmundaceae which was very abundant in Tasmania during mid-Mesozoic time.

**Key Words:** Osmundaceae, *Millerocaulis*, Little Swanport, Tasmania, Mesozoic.

### INTRODUCTION

Osmundaceae is significant among fern families due to its extensive fossil record, both as leaf compressions and petrified axes and rhizomes. The latter are characterised by having stems with adhering leaf bases and attached adventitious roots (Miller 1967, 1971). The family was particularly important in floras of mid-Mesozoic age in Tasmania (Hill *et al.* 1989, Tidwell 1987, Tidwell & Jones 1987, Tidwell *et al.* 1987, 1991).

One genus of petrified rhizomes in this family is *Millerocaulis* (Tidwell 1986), which has been reported previously from the Triassic through the Lower Cretaceous in Argentina (Archangelsky & De La Sota 1962, 1963), South Africa (Seward 1907), New Zealand and Australia (Gould 1981, Kidston & Gwynne-Vaughan 1907, Tidwell *et al.* 1991, Stopes 1921), Antarctica (Schopf 1978), India (Gupta 1970, Mittre 1955, Sharma 1973, Sharma *et al.* 1979), Peoples Republic of China (Wang 1983), and USA (Tidwell & Rushforth 1970). Species of this genus reported from Tasmania (Tidwell *et al.* 1991) are *M. johnstonii*, *M. spinksii*, *M. websterii*, *M. broganii*, and *M. swanensis*, all from three sites along the eastern coast, and *M. wrightii* from the Lune River locality.

The present report describes a new species of *Millerocaulis* based on a single specimen of silicified rhizome from mid-Mesozoic of Tasmania. This is the third, but the first new, species, reported from localities near Little Swanport. The two species reported earlier from this area are *M. johnstonii* and *M. broganii* (Tidwell *et al.* 1991) with the latter species being collected from the same locality as the specimen upon which this report is based.

### MATERIALS AND METHODS

The new species is based upon one black, permineralised specimen from gravels in a small area to the west of Mitchelmores Creek, which lies east of the River Road southwest of Little Swanport (g.c.  $42^{\circ} 20' 45''$  S,  $147^{\circ} 53' 48''$  E and UGR 55G EP735113: *Little Swanport* 1:100 000 sheet 8413). The study of the specimen was based mainly on thin sections viewed through a transmitted light microscope. Part of the specimen was also examined under reflected light after being etched with hydrofluoric acid. The age of the locality, other than mid-Mesozoic, remains uncertain.

The specimen is deposited in the Tasmanian Museum and Art Gallery, Hobart, Tasmania.

### SYSTEMATIC PALAEOBOTANY

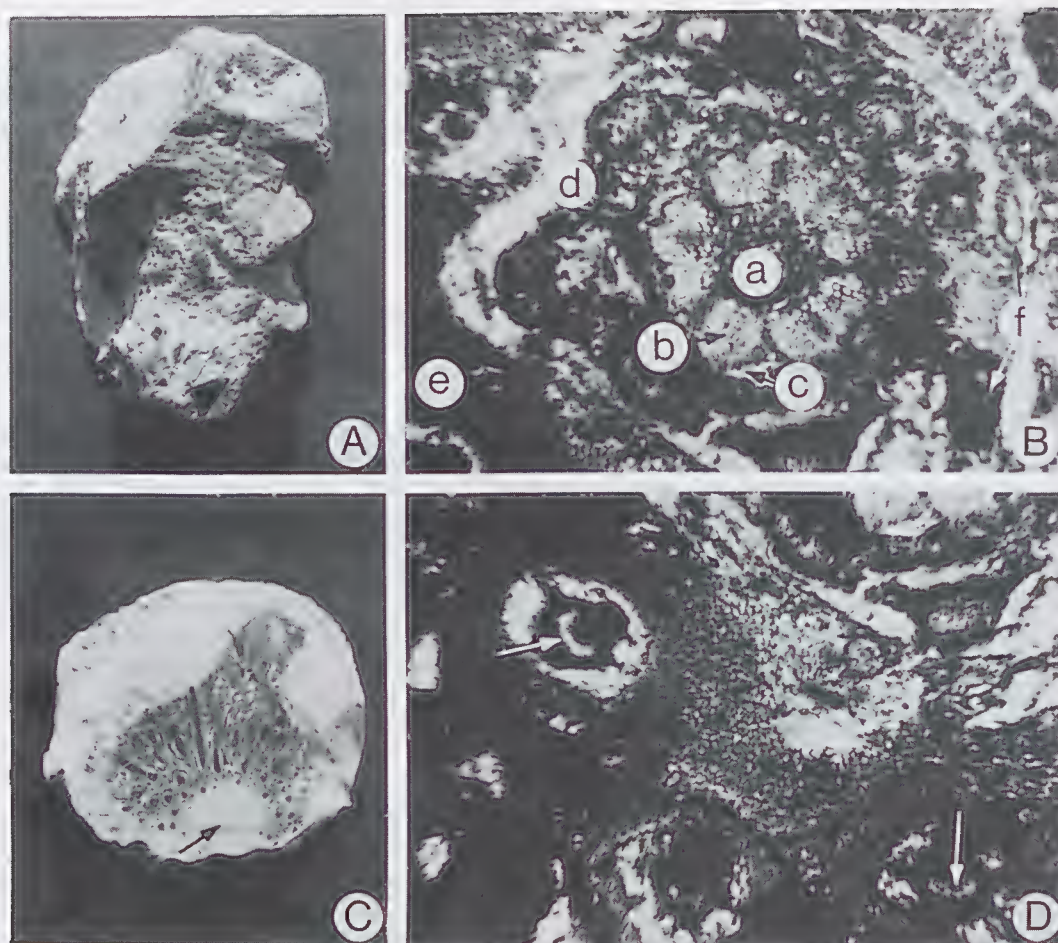
#### Osmundaceae

*Millerocaulis richmondii* sp. nov.

(pls 1–3, figs 1, 2)

#### Diagnosis

Stem rhizomatous,  $6 \times 7$  mm across, surrounded by a mantle of closely adhering stipulated leaf bases; stele ectophloic siphonostele; xylem cylinder dissected, consisting of 14 xylem strands (five strands by Hewitson's [1962] method); pith parenchymatous, 1 mm across; three leaf gaps high and wide, formed opposite departing trace; phloem and external endodermis continuous; inner cortex parenchymatous, homogeneous, 0.75–1.25 mm wide; outer cortex, 1.5–3 mm across; 20 leaf traces per transverse section of cortices; leaf trace C-shaped, single, medial, adaxial protoxylem cluster bifurcating upon initially entering petiole; petiole base stipular; sclerotic ring homogeneous; expanded sclerotic mass in



## PLATE 1

*Millerocaulis richmondii* sp. nov. (A) Side view of holotype Z2334,  $\times 1$ . (B) Transverse section of the stem. Note the pith (a), xylem (b), phloem and endodermis (c), inner cortex (d), outer cortex (e), and leaf traces (f),  $\times 23$ . (C) Top view of holotype. Note the smallness of the stem (arrow) surrounded by petioles,  $\times 1$ . (D) Transverse section illustrating the sclerenchymatous outer cortex containing leaf traces (arrows),  $\times 23$ .

concavity of petiolar vascular strand, filling concavity distally and connecting with sclerotic ring; single large, round cellular mass in each stipular expansion; roots diverging two per leaf trace, stele exarch.

## Repository

Tasmanian Museum and Art Gallery Z2334 (holotype); Hobart, Tasmania.

## Etymology

The specific epithet honours Mr John Richmond of South Hobart, Tasmania, for donating the specimen.

## Locality

Mitchelmores Creek, south of Little Swanport, Tasmania.

## Age

Uncertain, in Holocene gravel derived from older source rock.

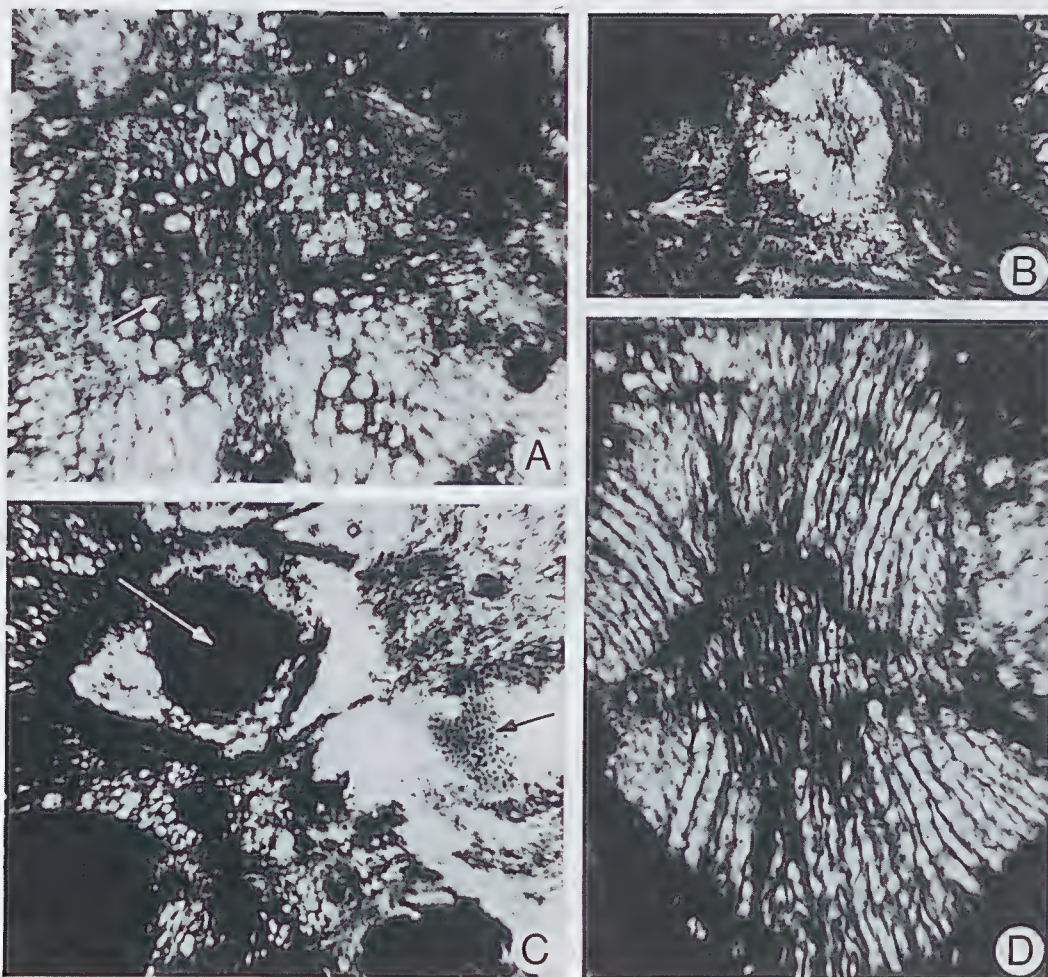
## Description

The stem of *Millerocaulis richmondii* is small,  $6 \times 7$  mm across, with a stele having an external diameter of 2 mm and apith 1 mm across (pl. 1 A–C, fig. 1). Thin-walled parenchyma

cells, 20–65  $\mu\text{m}$  across, comprise the pith. Smaller parenchyma cells arranged in a single layer of the xylem sheath enclose the pith, extend into the leaf gaps and separate the phloem from the xylem. Thin-walled cells of the leaf gaps are generally uniform in shape and size, becoming larger towards the outside of the xylem cylinder.

The xylem cylinder is dissected and is composed of 14 oval xylem strands that are 8–10 metaxylem tracheids in radial width. These strands appear as single strands or horseshoe shaped, with their open ends towards the pith, during trace formation and are composed of scalariform metaxylem tracheids measuring 20–40  $\mu\text{m}$  wide by 150  $\mu\text{m}$  long. Protoxylem elements are 10–15  $\mu\text{m}$  across, and no xylem parenchyma is present.

The divergence of the leaf trace from the stele begins with a small amount of parenchyma being inserted between two fused xylem strands, and a protoxylem strand also occurs at this point. This parenchyma develops centripetally, ultimately connecting with the pith and, thus, splitting the strands. The U-shaped part of these strands separates to form the trace, with one side diverging before the other; eventually the other side of the trace breaks away and the characteristic C-shape leaf trace results (pl. 2A). A single protoxylem cluster remains endarch on the inner face of the



## PLATE 2

*Millerocaulis richmondii* sp. nov. (A) Longitudinal view of leaf trace departing xylem. Note the scalariform pittings (arrow) on the tracheid walls,  $\times 75$ . (B) Transverse section of a coniferous root that occurred among the petiole bases,  $\times 25$ . (C) Closeup of a transverse section of petioles with stipular wings attached. Note the sclerenchyma (arrows) in the adaxial concavity of the vascular strands,  $\times 25$ . (D) Closeup of the root (B). Note tracheids in radial rows,  $\times 75$ .

curved trace until it bifurcates immediately outside of the stem.

Phloem, 1–3 cells wide, occurs external to the xylem sheath (pl. 1B). The phloem cells are oblong in transverse shape and measure  $7 \times 15\text{--}20\text{ }\mu\text{m}$  across. Whether this shape is natural or due to preservation cannot be determined. The phloem is V-shaped at the leaf gaps, with the apex of the V projecting into the gap. Internal phloem is absent. A layer of thin-walled, oblong cells, with each cell being  $75 \times 1.25\text{ }\mu\text{m}$  across, is interpreted as the endodermis. This tissue occurs around the stele and outlines the leaf traces as they pass through the inner cortex.

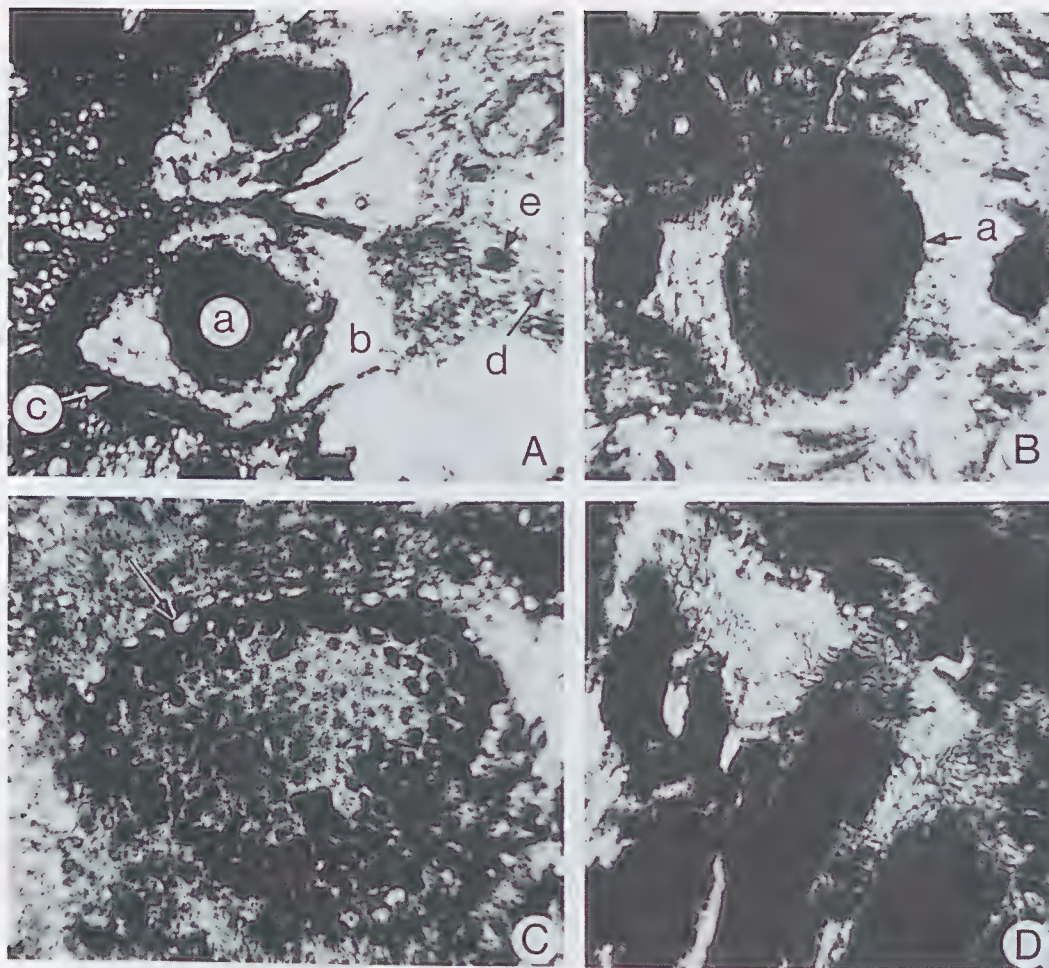
Thin-walled parenchyma cells,  $25\text{--}50\text{ }\mu\text{m}$  in diameter, lying outside of the endodermis, comprise the inner cortex (pl. 1B, D). No sclerenchyma appears to be present. In this tissue of about  $0.75\text{--}1.25\text{ mm}$  in thickness, 13 leaf traces can be observed. Outer cortex in this species is a sclerenchymatous tissue of thick-walled cells,  $35\text{--}55\text{ }\mu\text{m}$  across, and contains seven leaf traces (pl. 1D). This tissue is  $1.5\text{--}3\text{ mm}$  thick, with its actual width difficult to define because of emerging leaf traces.

Passing from the stele towards the periphery of the stem,

the leaf trace begins somewhat flattened near the stele in the inner cortex, becoming strongly curved towards the outside of this tissue, and remaining this shape throughout the outer cortex (pl. 1D).

The xylem in the emerging traces is generally thin, consisting of 2–3 tracheids in width near their middles, and upwards of 5 tracheids at their tips. The phloem is abaxial to the xylem and the endodermis is external to the phloem in these vascular strands. A sclerotic ring surrounds the trace as it leaves the outer cortex. Cells constituting this ring are uniform in size and wall thickness.

A cluster of sclerotic cells occurs in the adaxial concavity of the petiolar vascular strand in the outer cortex (pls 2C, 3A–D). At the base of the petiole, the cluster is small, round, and placed in the middle of the inner cortex of the petiole (fig. 2). Distally it becomes broader and then flattened against the vascular strand (pl. 2B). At a higher level of the petiole, the cluster expands adaxially until it ultimately becomes part of the sclerotic ring (fig. 2). It also widens abaxially, filling the concavity of a broadly flattened strand. This expanded sclerotic cluster starts somewhat triangular in shape,  $0.5\text{ mm}$  across with rounded angles, and higher up



## PLATE 3

*Millerocaulis richmondii* sp. nov. (A & B) Close-ups of transverse sections of petioles with stipular wings attached. Note the sclerenchyma in the adaxial concavity of the petiolar strand (a), inner cortex of the petiole (b), sclerotic ring (c), the stipular wing (d), and the mass of sclerenchyma in the wing (e),  $\times 25$ . (C) Enlargement of the sclerenchyma in the adaxial concavity of the petiolar vascular strand (arrow),  $\times 25$ . (D) Longitudinal view of several petioles. The long black objects are the sclerenchyma in the petiolar strands and the wavy cells compose the stipular wings,  $\times 75$ .

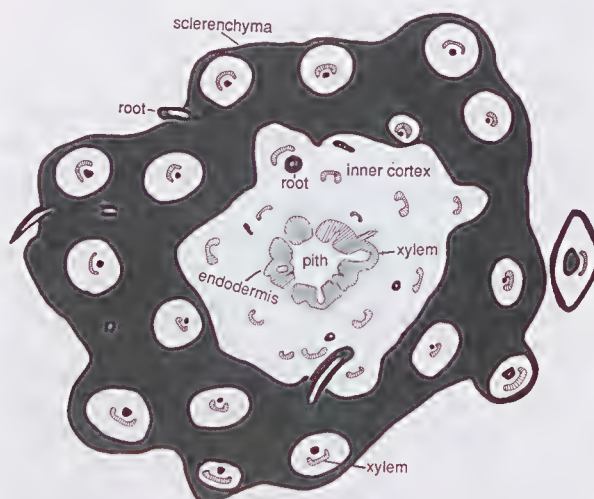


FIG. 1—*Millerocaulis richmondii* sp. nov. Transverse section of the stem with one petiole.  $\times 12.5$ .

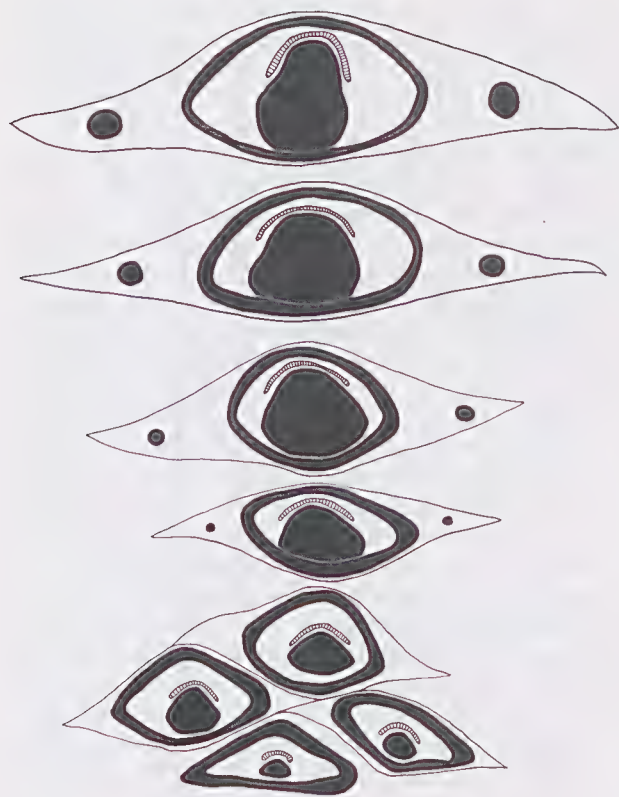


FIG. 2 — *Millerocaulis richmondii* sp. nov. Transverse sections of petioles with stipular wings attached illustrating changes that occur at progressively higher levels of the petioles. Note how the sclerenchyma in the adaxial concavity of the vascular strand and the sclerenchyma mass in the wing enlarges upwards in the petiole. Black = sclerenchyma.

is oblong and 1 mm wide. The parenchyma cells of the inner cortex of the petiole are round, 25–30  $\mu\text{m}$  wide (pl. 3A). No other sclerenchyma is present in the inner cortex of the petioles.

Leaf bases are stipular with the expansions at lower levels being relatively short, but become elongated upwards. They measure 2–3 mm from the sclerotic ring to their tip. The parenchyma cells making up the wing are distorted (pl. 3D) and measure 50–60  $\mu\text{m}$  across. The epidermis of these wings is poorly preserved and can be defined by a black line 2  $\mu\text{m}$  wide. A large, round cellular mass of sclerenchyma, 100–200  $\mu\text{m}$  across, occurs midway between the ring and the tip of the stipular wing (pl. 3A). This mass is small at lower levels, becoming three times as large at higher ones.

Surprisingly, only a small number of roots occur in this specimen. They are exarch and protostelic, and arise from the leaf trace before the traces leave the stele. The xylem of the roots begins round and eventually becomes elliptical. Metaxylem trachery elements in these protosteles are 20–30  $\mu\text{m}$  in diameter and 120  $\mu\text{m}$  long. The phloem, pericycle, endodermis and inner cortex are not preserved. The sclerotic outer cortex consists of thick-walled cells 15  $\mu\text{m}$  across. The epidermis is also not preserved. Most of the roots were sectioned longitudinally in transverse stem sections, suggesting a rhizomatous nature for the stem (Miller 1971).

An unidentifiable root occurs among the petiole bases in the specimen (pl. 2B, D). The root measures 0.75  $\times$  1 mm

across, with tracheids arranged in radial rows, and appears to be from a conifer, because of its secondary growth and its xylem composition being only tracheids.

## COMPARISONS AND DISCUSSION

*Millerocaulis richmondii* differs most significantly from the other members of *Millerocaulis* in the amount of sclerenchyma in the adaxial concavity of its leaf and petiolar traces. None of the others consistently have the large amount of sclerenchyma that is present in *M. richmondii*. The species closest to having this amount is *M. wadei* (Tidwell & Rushforth 1970) Tidwell from the Upper Jurassic Morrison Formation in eastern and central Utah, USA. Most petioles of the latter species contain sclerenchyma flattened against their vascular strands. In some petioles, however, the masses broaden adaxially, like those in *M. richmondii*, to become part of, or at least be appressed into the sclerotic cylinder surrounding the strand. These large masses of sclerenchyma do not occur in all the petioles of *M. wadei* as they do in *M. richmondii*.

*Millerocaulis richmondii* is similar to the Tasmanian species *M. spinksii*, *M. broganii*, and *M. johnstonii* in its size and the trace number in its cortices (table 1), but differs from them in possessing a large mass of sclerenchyma in the concavity of its petiolar strand, in lack of sclerenchyma in the wings of *M. spinksii*, the more numerous xylem strands and the heterogeneous pith of *M. broganii*, and the heterogeneous sclerotic ring and sclerenchyma lining the petiole strand in *M. johnstonii* (table 1).

This new species from Tasmania also differs from other species of *Millerocaulis* from the Southern Hemisphere. It is unlike *M. dunlopia* (Kidston & Gwynne-Vaughan 1907) Tidwell and *M. gibbiana* (Kidston & Gwynne-Vaughan 1907) Tidwell, both from Queensland, Australia and New Zealand, in having only one mass in its wings rather than numerous small masses as in *M. dunlopia* and 12 linear ones in *M. gibbiana*. It has a homogeneous sclerotic ring rather than the heterogeneous ring of *M. kidstonii* (Stopes 1921) Tidwell from Queensland. It is also not arborescent like *M. kolbei* (Seward 1907) Tidwell of South Africa. *Millerocaulis patagonica* (Archangelsky & De La Sota 1962) Tidwell and *M. herbstii* (Archangelsky & De La Sota 1963) Tidwell of South America have more numerous masses of sclerenchyma in their wings (10 in *M. patagonica* and 3–5 in *M. herbstii*) as compared to one in *M. richmondii*.

*Millerocaulis beardmorensis* (Schopf 1978) Tidwell from Antarctica differs by having a mixed pith which does not occur in this Tasmanian species.

Of the seven species described from Tasmania, *M. richmondii* is anatomically intermediate (table 1). Based upon fourteen characters proposed by Miller (1971) for judging whether an osmundaceous form is primitive or advanced, *M. richmondii* has seven that are primitive and six that are advanced, with one being intermediate. The primitive characters in *M. richmondii* are a homogeneous, parenchymatous pith, external endodermis and phloem, parenchymatous inner cortex, protoxylem bifurcating in petiole, a single, albeit large, mass of sclerenchyma in the concavity of its petiolar strands, homogeneous sclerotic ring, and having a single mass of sclerenchyma in each stipular wing. Its advanced characters are a rhizomatous habit, low number of xylem strands and a thin xylem cylinder, thick outer and thinner inner cortex, as well as a

Table 1  
Comparison of the *Millerocalis* species from Tasmania with *M. richmondii*.\*

| Species/<br>locality†            | Stem<br>size<br>(mm) | Pith<br>(mm)     | Xylem<br>cylinder<br>width<br>(mm) | Xylem<br>strand<br>no.     | Inner<br>cortex<br>(mm) | Outer<br>cortex<br>(mm) | Trace<br>no.               | Scler. in<br>concavity | Scler. in<br>cortex | Scler.<br>ring | Scler. in<br>wing                | PX<br>divides      | Root<br>origin  |
|----------------------------------|----------------------|------------------|------------------------------------|----------------------------|-------------------------|-------------------------|----------------------------|------------------------|---------------------|----------------|----------------------------------|--------------------|-----------------|
| <i>M. richmondii</i><br>Loc. 4   | 6x7                  | homog.<br>1      | 2<br>8-10 tr.                      | 14                         | homog.<br>0.75-1.25     | 1.5-3                   | 20                         | fills<br>oblong        | none                | homog.         | 1 mass                           | petiole            | l.tr.<br>n.st.  |
| <i>M. wrightii</i><br>Lune River | 18-20                | homog.<br>4      | 0.5-1<br>9-15 tr.                  | 50-55<br>(21H)             | homog.<br>2-4           | 3-5                     | 50                         | 2 near<br>trace        | none                | homog.         | 1 mass<br>2-4 linear             | petiole            | l.tr.<br>n.st.  |
| <i>M. johnstonii</i><br>Loc. 1,3 | 10                   | homog.<br>0.25   | 0.5<br>7-10 tr.                    | 17(6H),<br>8(3H)<br>branch | homog.<br>1             | 3                       | 25                         | lining                 | none                | heterog.       | 1 mass                           | petiole            | l.tr.<br>n.st.  |
| <i>M. pinksterii</i><br>Loc. 2   | 9-12<br>brnchg       | homog.<br>0.75-1 | 0.5-1.25<br>8-14 tr.               | 27,14(3H)<br>branch        | homog.<br>0.75-1.25     | 1.5-2                   | 11-18<br>23 in<br>paratype | none                   | none                | homog.         | none                             | petiole            | l.tr.<br>cortex |
| <i>M. websterii</i><br>Loc. 2    | 15-17                | homog.<br>3      | 1<br>12-15 tr.                     | 28-29(7H)                  | homog.<br>0.5-2         | 4                       | 56                         | none                   | none                | homog.         | gen. none<br>1 mass<br>very rare | petiole            | l.tr.<br>cortex |
| <i>M. broganii</i><br>Loc. 2,4   | 7-8<br>brnchg        | heterog.<br>0.5  | 0.5<br>8-12 tr.                    | 20-24<br>(6-8H)            | homog.<br>0.75-1        | 1-2                     | 28-29                      | 2 near<br>trace        | none                | homog.         | 1 mass                           | inner<br>cortex(?) | l.tr.<br>n.st.  |
| <i>M. swanensis</i><br>Loc. 2    | 3-6<br>brnchg        | homog.<br>0.25   | 0.25<br>7-9 tr.                    | 10(3-4H)<br>branch         | homog.<br>0.3-0.5       | 0.75-1                  | 6-8                        | 2 near<br>trace        | none                | homog.         | 1 mass                           | petiole            | l.tr.<br>n.st.  |

\* Modified from Tidwell *et al.* 1991.

† Localities: 1 – A gravel pit north of the Lake Leake Road. 2 – Gravels in a road cutting (road cut) and surrounding area on Coles Bay Road, north of the Swanwick turnoff. 3 – Floodplain of White Hut Creek, Little Swanport. 4 – Gravels on bank of Mitchelmores Creek (for more data see Tidwell *et al.* 1991).

Abbreviations: brnchg = branching, homog. = homogeneous, scler. = sclerenchyma, l.tr. = leaf trace, H = number by Hewitson's (1962) method, heterog. = heterogeneous, PX = protoxylem, n.st. = near stele, tr. = tracheid.

large amount of sclerenchyma in the plant (Wagner 1964), although there is none in the inner cortex of the petiole.

Distribution of sclerenchyma in the leaf bases and stipular wings in species of the Osmundaceae have been considered to be the most dependable anatomical taxonomic characters upon which to base their separation (Hewitson 1962, Miller 1967, 1971). In general, this appears to be true. However, five species (*M. wadei*, *M. johnstonii*, *M. broganii*, *M. swanensis* and *M. richmondii*) all have similar single masses of sclerenchyma in their stipular wings and seven (*M. patagonica*, *M. kidstonii*, *M. dunlopii*, *M. gibbiana*, *M. wrightii*, *M. broganii* and *M. swansensis*) similarly have two adaxial sclerenchyma masses against the tips of their petiolar vascular strands. Thus, these characters may not always be as distinct as originally thought. These species are distinguished by other characters. However, this illustrates how, in general, species in this family should not be distinguished only on one feature, but rather should be separated on a composite of several different ones.

The age of *M. richmondii* and most of the other Tasmanian species of *Millerocaulis* is unknown. At present, there appears to be a good chance they came from the Upper Triassic (Tidwell *et al.* 1991). However, anatomically this group of species appears to be rather advanced to be this age. Since their source is unknown, their actual age and how they fit phylogenetically into the Osmundaceae must await more conclusive stratigraphic evidence.

## REFERENCES

- ARCHANGELSKY, S. & DE LA SOTA, E.R., 1962: Estudio anatomico de un estipite petrificado do "*Osmundites*", de edad Jurasica, procedente del Gran Bajo de San Julian, Provincia de Santa Cruz. *Ameghiniana* 2(9): 153–164.
- ARCHANGELSKY, S. & DE LA SOTA, E.R., 1963: *Osmundites herbstii*, nueve petrificacion Triasica de el Tranquilo, Provincia de Santa Cruz. *Ameghiniana* 3(5): 135–140.
- GOULD, R., 1981: The coal-forming flora of the Walloon coal measures. *Coal Geol. (Aust.)* 1: 83–105.
- GUPTA, K. M., 1970: Investigations on the Jurassic flora of the Rhajmahal Hills, India. 8. On a new species of *Osmundites raimahalense* sp. nov. from the Rhajmahal Hills, Bihar (India). *Palaeontographica* 130B: 173–180.
- HEWITSON, W.H., 1962: Comparative morphology of the Osmundaceae. *Ann. Missouri Bot. Garden* 49: 57–93.
- HILL, R.S., FORSYTH, S.M. & GREEN, F., 1989: A new genus of osmundaceous stem from the Upper Triassic of Tasmania. *Palaeontology* 32: 287–296.
- KIDSTON, R. & GWYNNE-VAUGHAN, D.T., 1907: On the fossil Osmundaceae, Part I. *Trans. R. Soc. Edinburgh* 45: 759–780.
- MILLER, C.N., 1967: Evolution of the fern genus *Osmunda*. *Contrib. Mus. Paleontology Univ. Michigan* 21(8): 139–203.
- MILLER, C.N., 1971: Evolution of the fern family Osmundaceae based on anatomical studies. *Contrib. Mus. Paleontology Univ. Michigan* 28: 105–169.
- MITTRE, V., 1955: *Osmundites sabbii* sp. nov., a new species of petrified osmundaceous rhizomes from India. *The Palaeobotanist* 4: 113–118.
- SCHOPF, J.M., 1978: An unusual osmundaceous specimen from Antarctica. *Can. J. Bot.* 56: 3083–3095.
- SEWARD, A.C., 1907: Notes on fossil plants from South Africa. *Geol. Mag. N.S.* 4: 481–487.
- SHARMA, B.D., 1973: Anatomy of osmundaceous rhizomes collected from the Middle Jurassic of Amajola in the Rajmahal Hills, India. *Palaeontographica* 140B: 150–160.
- SHARMA, B.D., BOHRA, D. & SINGH, R., 1979: *Osmundacaulis estipulare* sp. nov., a petrified rhizome from Jurassic of Rajmahal Hills, India. *Phytomorphology* 29: 46–52.
- STOPES, M.C., 1921: The missing link in *Osmundites*. *Ann. Bot.* 35: 55–61.
- TIDWELL, W.D., 1986: *Millerocaulis*, a new genus with species formerly in *Osmundacaulis* Miller (fossils: Osmundaceae). *Sida* 11(4): 401–405.
- TIDWELL, W.D., 1987: A new species of *Osmundacaulis* (*O. jonesii* sp. nov.) from Tasmania, Australia. *Rev. Palaeob. Palynol.* 52: 205–216.
- TIDWELL, W.D. & JONES, R., 1987: *Osmundacaulis nerii*, a new osmundaceous species from Tasmania, Australia. *Palaeontographica* 204B: 181–191.
- TIDWELL, W.D. & RUSHEFORTH, S.R., 1970: *Osmundacaulis wadei*, a new osmundaceous species from the Morrison Formation (Jurassic) of Utah. *Bull. Torrey Bot. Club* 97(3): 137–144.
- TIDWELL, W.D., KIM, J. & KIMURA, T., 1987: Mid-Mesozoic leaves from near Ida Bay, southern Tasmania, Australia. *Pap. Proc. R. Soc. Tasm.* 121: 159–170.
- TIDWELL, W.D., MUNZING, G.E. & BANKS, M.R., 1991: *Millerocaulis* species (Osmundaceae) from Tasmania, Australia. *Palaeontographica* 223B: 91–105.
- WAGNER, W.H. JR., 1964: The evolutionary patterns of living ferns. *Mem. Torrey Bot. Club* 21(5): 86–95.
- WANG, Z., 1983: *Osmundacaulis hebeiensis*, a new species of fossil rhizomes from the Middle Jurassic of China. *Rev. Palaeob. Palynol.* 39: 87–107.

(accepted 9 August 1991)



TWO *MONOGRAPTUS* SPECIES FROM THE PŘÍDOLÍ OF WESTERN TASMANIA

R.B. Rickards and M.R. Banks

(with one text-figure and one plate)

RICKARDS, R.B. & BANKS, M.R., 1992 (31:x): Two *Monograptus* species from Přídolí the of western Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 9–11. ISSN 0080–4703. Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, United Kingdom (RBR); Department of Geology, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001 (MRB).

*Monograptus parvultimus* Jaeger and *M. cf. fragmentalis* Bouček in siltstone with sparse shelly fossils in the Eldon Group near Bubs Hill, western Tasmania, indicate a basal Přídolí age.

**Key Words:** *Monograptus*, Silurian, western Tasmania.

## INTRODUCTION

Thomas (1960: pl. xiv) figured as *Monograptus* spp. specimens collected by one of the authors (MRB) prior to December 1956 from fawn to red siltstone in road cuts near the Q15 milepost on the Lyell Highway, about 1.75 km WNW of Bubs Hill, western Tasmania (*Franklin* 1:100 000 sheet 8013-971373, Department of Lands, Hobart). He identified them in the text (Thomas 1960: 15) as *M. colonus et var.*, indicative of a Lower Ludlow age. These fossils came from a talus slope about 75 m on the Hobart side of the milepost, in a siltstone with ripple marks, brachiopods, bivalves, ostracodes, trilobites and crinoid fragments; from a cut about 33 m on the Hobart side of the milepost and from a small quarry 8 m on the Queenstown side of the milepost. The beds containing these fossils were ascribed to the Bell Shale (uppermost formation of the Eldon Group of Gill & Banks, 1950) by Thomas (1960: 15), whereas Banks (1962: 181) correlated them with the Austral Creek Siltstone. This formation, which had been recently recognised by Blissett (1962) at Zeehan, lies under the Florence Quartzite, the formation beneath the Bell Shale. The Lyell Highway locality is shown as a correlate of the Amber Slate on the Department of Mines 1:50 000 geological map *Lyell* (Calver *et al.* 1987). The Amber Slate is separated from the Austral Creek Siltstone by the Keel Quartzite.

Reid (1964: 38, 39) reported monograptids in light-brown, fissile, fossiliferous siltstone at 780 m (approx.) a.s.l. on a timber track northwest of Bubs Hill, at a locality with coordinates *Franklin* 8013–98403875. The fossiliferous unit is overlain by a thin, fine-grained quartzite, a black unfossiliferous siltstone and then a correlate of the Florence Quartzite, the base of which is 32 m topographically above the graptolitic unit. With the graptolites in the siltstone are rugose corals, brachiopods, ophiuroids, asteroids, crinoids and hyolithids. Reid ascribed the fossiliferous siltstone to the Austral Creek Formation. Banks (in Talent & Banks 1967: 158–159), following Reid, reported *Maoristrophia* sp., *Notoleptaena* sp., *Dalmanites cf. wandongensis* and *Monograptus vulgaris curtus*, the *Dalmanites* from the Lyell Highway locality. As with the unit on the Lyell Highway, this siltstone was shown on the Lyell geological sheet as an Amber Slate correlate. The Amber Slate is regarded as late Llandovery or Wenlock (Baillie 1989: 225, 232). Baillie (*ibid.*: 232) commented that the Ludlow age ascribed earlier to the graptolites should be treated with caution.

The graptolites collected by Reid were sent away soon after collection for expert identification but were mislaid until they were recovered through the good offices of Dr Barry Webby in mid-1989, after which they were drawn to the attention of the senior author (RBR). A few identifiable fragments have since been found in the road cut.

## PALAEONTOLOGY

*Monograptus cf. fragmentalis* Bouček, 1936  
(fig. 1A and pl. 1A)

- 1936 *Monograptus fragmentalis* n. sp.; Bouček, 7, text figs. 11–n.
- 1943 *Pristiograptus fragmentalis* (Bouček, 1936); Přibyl 27–28; text fig. II, R.S.
- 1967 *Monograptus vulgaris curtus* Elles & Wood; Banks in Talent & Banks: 158.
- 1976 *Pristiograptus fragmentalis* (Bouček); Bouček, Mihajlovic and Veselinovic, 88–91; pl. 2, figs 1–7; pl. 3, fig. 1; text figs 2a–e.
- 1986 *Monograptus fragmentalis* Bouček, 1936; Jaeger, 1986, 316; pl. 2, figs 14–15, 18, 20–21.

## Material

About twenty specimens, including fragments possibly referable to this form, occur on slabs, Department of Geology, University of Tasmania catalogue numbers 80821, 80838 and 80856. Possible fragments also occur on 80869 and 80872. All specimens are from one locality, a timber track near Bubs Hill, western Tasmania (coordinates of locality: *Franklin* 8013–98403875, approximately 42° 06' S, 145° 46' E).

## Associates

Occurs with *M. cf. parvultimus*.

## Horizon

Eldon Group.

## Remarks

The material seems to be quite close to that recently described by Jaeger (1986) from the type Přídolí region. There are proximal and distal fragments, which do not occur on the same specimen, but which have similar thecal type and are

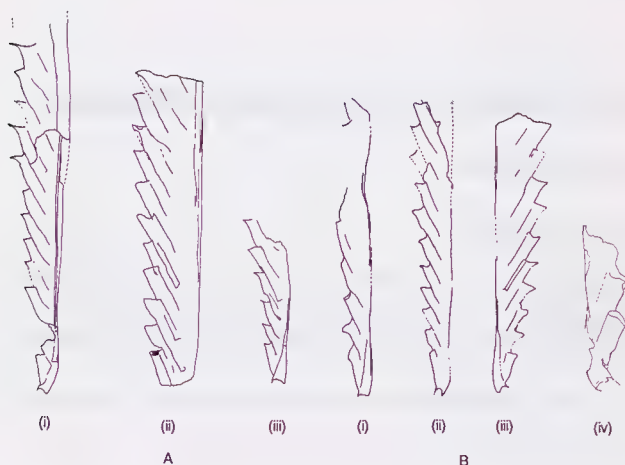
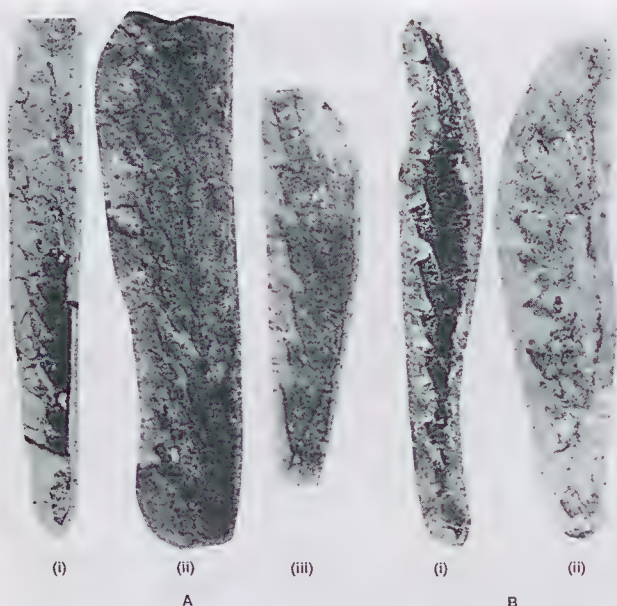


FIG. 1 — (A) *M. cf. fragmentalis* Bouček: (i) UTGD 80856, × 4; (ii) UTGD 80855, × 4; (iii) UTGD 80881, × 4; all from timber track. (B) *M. parultimus* Jaeger: (i) UTGD 80872, × 4; (ii) UTGD 80850, × 4; (iii) UTGD 80848, × 4; (iv) UTGD 124100, × 4; (i), (ii) and (iii) from the timber track, (iv) from cutting on the Lyell Highway.



#### PLATE 1

(A) *M. cf. fragmentalis* Bouček: (i) UTGD 80856, × 8; shows rhabdosomal form, thecal overlap and strongly "denticulate" thecal margin; this specimen is unusual in having a curved sicula; mostly they are almost straight; (ii) UTGD 80855, × 12; mesial and distal thecae showing considerable thecal overlap and slightly "denticulate" thecal apertures; (iii) UTGD 80821, × 10; shows well-preserved proximal end with typically straight, long sicula and considerable thecal overlap. (B) *M. parultimus* Jaeger: (i) UTGD 80850, × 8; ventral part of stipe well-preserved, with sicular aperture visible and curvature of sicula traceable; undulating thecal apertures also visible, especially of th1, th2 and th6; (ii) UTGD 80850, × 12; indifferently preserved specimen, but showing undulating thecal apertures quite well, at least up to th6.

probably the same form. The proximal thecal overlap begins at about the level of the aperture of the preceding theca; in the distal, fragments reach just below the aperture of the preceding theca. (Thus, a section just above the thecal apertures will traverse three thecal tubes before the dorsal margin/nema is reached.) This is a slightly greater thecal overlap than indicated by Jaeger, but the thecal spacing, at 12 in 10 mm, is well within the range quoted. The proximal end is rather *dubius*-like and varies from almost straight to (usually) gently ventrally curved. The sicula itself is almost 2 mm long and its apex is just below the aperture of the second theca. In subdorsal view (fig. 1), some specimens show what appear to be apertural denticles, but this is certainly a feature of the particular view and a degree of diagenetic flattening; in the true profile, none of the thecae show denticles, though there is a suggestion of very gently undulating apertural rims. The dorsoventral width exceeds 2.5 mm even in fragments preserved in three dimensions. As far as we are aware, these are the first recordings from Australia of forms related to this species. In Europe (Jaeger 1986), *M. fragmentalis* usually occurs in the latest Ludlow, immediately below the *parultimus* Zone at the base of the Prídolí, but the species is known to overlap with *M. parultimus* in one location (Serbia).

#### *Monograptus parultimus* Jaeger, 1975 (fig. 1B and pl. 1B)

- 1899 *Monograptus ultimus* n. sp.; Perner, 13–14, pl. 16, figs 4, 5?, 11a, b (non text-figs 14a, b = *M. ultimus*)  
 1940 *Monograptus (Pristiograptus) ultimus* Perner; Přibyl, pl. 1, figs 9, 10, ?11.  
 ?1974 *Pristiograptus (?) ultimus* (Perner); Paskevicius, fig. 1, plate 14, figs 3–8.  
 1975 *Monograptus parultimus* n. sp.; Jaeger, 119–125; text-fig. 4, p. 2, fig. 4, 8.  
 1976 *Pseudomonoclimacis ultimus* (Perner); Tsegel'nyuk, 106, p. 30, figs 10–12.  
 1976 *Pseudomonoclimacis podolicus* sp. nov.; Tsegel'nyuk, 106–107, p. 31, figs 1–3.  
 1979 *Monoclimacis parultimus* (Jaeger); Paskevicius, 160–2, pl. 10, figs 1–5; pl. 24, figs 16–19; pl. 25, figs 1–5.  
 1983 *Ludensograptus parultimus* (Jaeger); Tsegel'nyuk, 94, 145.  
 1986 *Monograptus parultimus* Jaeger, 1975; Jaeger, 318–321, text-figs 29–34; pl. 1, figs 1–2, 8–9; pl. 2, figs 3–6, 23–24; pl. 4, fig. 12.

#### Material

There are five fairly well-preserved specimens, in three dimensions with fine mud infills, and a further fifteen or so fragments may be referable to this form, on Department of Geology, University of Tasmania, slabs 80848, 80850, 80854, 80855, 80872. All these specimens are from the locality given for *M. cf. fragmentalis* above. There are also two fragments from the road cutting on the Lyell Highway, 50022 and 124100.

#### Associates

It occurs with *M. cf. fragmentalis* Bouček.

#### Horizon

Eldon Group.

## Remarks

*M. parultimus* is distinguished from *M. cf. fragmentalis* at the same locality by the presence of rounded thecal apertures or undulating thecal margins. The sicula, although of similar dimensions and position, is almost always strongly curved in a ventral sense, with a strong dorsal tongue. Only a few specimens are almost straight, though the rhabdosome itself is proximally straighter than in *M. cf. fragmentalis*. The thecal dimensions, spacing, and overall appearance of the colony, preserved in moderate three dimensions, are close to the figures given by Jaeger (1986). The only difference we can detect is that the gentle sigmoidal curvature of the thecae is even less conspicuous than in Jaeger's material. Nevertheless, it is present. The early growth of the first theca is typically upwards at a low angle, but perhaps the sicular apertural region is less isolated (i.e. the th 1 bud is lower down) than in Pridolí material. The preservation, in fact, may obscure both these differences, which may be more apparent than real. *M. parultimus* has not previously been recorded from Australia, and its association in some numbers with *M. cf. fragmentalis* does suggest an horizon at the base of the Pridolí, near the base of the *parultimus* Zone.

## SIGNIFICANCE

The fossils are significant in two respects — biogeographical and stratigraphical.

The recognition of these two species extends their geographical range to Australia. *M. fragmentalis* was recorded by Jaeger (1986) from Bohemia and Yugoslavia (eastern Serbia, Ruj Mountains and Potok Zajednica), the last being the Dubsky Potok of Bouček (1936). *M. parultimus* has been recorded by Jaeger (1986) from the eastern European platform in the Soviet Union, the Carnic Alps in Austria, and the Raj Mountains (eastern Serbia). It is at Potok Zajednica that the two species occur together, enabling us to suggest a horizon near the base of the Pridolí. Jaeger (1986) notes that *M. ultimus* occurs in four continents, but *M. parultimus*, as yet, is less widely recorded, perhaps because of its relatively more recent definition and the fact that in badly preserved material its definitive features might be missed: it would probably be then identified as *Pristiograptus dubius* (Suess), or as *M. ultimus* (e.g. Paskevicius 1974; see synonymy).

Stratigraphically, the age determination based on these two monograptid species removes the only evidence of Ludlow age for fossils in western Tasmania and provides support for Baillie's suggestion for a depositional hiatus in western Tasmania in the Ludlow (Baillie 1989: 232). However, it does raise the possibility (*contra* Baillie 1989: 233) that there is only a single major fining upward cycle in western Tasmania in the Llandovery and Wenlock, and two such major cycles in the Pridolí to Pragian or Emsian. A stratigraphic discontinuity at the base of the Keel Quartzite becomes a possibility.

## ACKNOWLEDGEMENTS

We are grateful to Doris Banks and Penny Partridge for assistance in collecting in the field.

## REFERENCES

- BAILLIE, P.W., 1989: Silurian and Devonian sediments. In Burrett, C. F. & Martin, E.L. (Eds): *GEOLOGY AND MINERAL RESOURCES OF TASMANIA*. Geol. Soc. Aust., Spec. Publ. 15: 224–233.
- BANKS, M.R., 1962: The Silurian and Devonian Systems. In Spry, A.H. & Banks, M.R. (Eds): *THE GEOLOGY AND MINERAL RESOURCES OF TASMANIA*. J. Geol. Soc. Aust. 9(2): 177–188.
- BLISSETT, H.A., 1962: *Zeehan, Tasmania*. Tasm. Dep. Mines 1 mile Geol. Atlas Ser., Explan. Rep., Sheet 50 (7914S).
- BOUČEK, B., 1936: La faune graptolithique du Ludlowien inférieur de la Bohême. *Bull. intern. Acad. Sci. Bohême* 1936: 1–16.
- BOUČEK, B., MIHAJLOVIC, M. AND VESELINOVIC, M., 1976: Graptolites of Upper Silurian and Lower Devonian of Zvonacka Banja (Eastern Serbia). *Glas ccxvii Acad. Serbe Sci. Arts. C7. Sci. Math. Nat.* 39: 79–114.
- CALVER, C.R. ET AL., 1987: *Lyell, Tasmania*. Tasm. Dep. Mines 1: 50,000 Geol. Atlas Ser., Sheet 8013N.
- GILL, E.D. & BANKS, M.R., 1950: Silurian and Devonian stratigraphy of the Zeehan area. *Pap. Proc. R. Soc. Tasm.* (1949): 259–271.
- JAEGER, H., 1975: Die Graptolithenführung in Silur/Devon des Cellon-Profiles (Karnische Alpen). *Carinthia II*, 165/185: 111–126.
- JAEGER, H., 1986: In Kriz, J. et al.: Pridolí — the Fourth Subdivision of the Silurian. *Jb. Geol. B.-A.* 129: 291–360.
- PASKEVICIUS, I.Y., 1974: Graptoliti i zonalnoe paschlenenie Ludlovskikh otloshchenii v pribaltike. Izdatelstuo 'Nauka'. Sibirskoe otdelenie Novosibirsk 1974. *Graptoliti SSSR Trudi I Osesoyznogo Kollokviuma*: 122–134, 164–188.
- PASKEVICIUS, J., 1979: *BIOSTRATIGRAPHY AND GRAPTOLITES OF THE LITHUANIAN SILURIAN*. Vilnius: 1–267.
- PERNER, J., 1899: *ETUDES SUR LES GRAPTOLITES DE BOHEME. III. Monographie des Graptolites de L'Etage E. Section b*. Prague: 1–24.
- PŘIBYL, A., 1940: Die Graptolithenfauna des mittleren Ludlow von Böhmen (oberes e B). *Vest. Stat. Geol. Ust. C.S.R.* 16: 63–73.
- PŘIBYL, A., 1943: Revision aller Vertreter der Gattung *Pristiograptus* aus der Gruppe *P. dubius* und *P. vulgaris* aus dem böhmischen und ausländischen Silur. *Mitt. tschech. Akad. Wiss.* 52/4: 1–49.
- REID, K.O., 1964: Geology of the Princess River area. Unpubl. B.Sc. Hons. Thesis, University of Tasmania.
- TALENT, J.A. & BANKS, M.R., 1967: Devonian of Victoria and Tasmania. In Oswald, D. H. (Ed.): *INTERNATIONAL SYMPOSIUM ON THE DEVONIAN SYSTEM*. Alberta Soc. Petrol. Geol. Calgary, Alberta II: 147–163.
- THOMAS, D.E., 1960: The zonal distribution of Australian graptolites. *Proc. R. Soc. NSW* 94: 1–58.
- TSEGELNJK, P.D., 1976: Late Silurian and Early Devonian Monograptidae of the south-west Ukrainian East-European Platform. *Palaeontology and Stratigraphy of the upper Precambrian and lower Palaeozoic of the south-western East-European Platform*, Kiev: 91–133.
- TSEGELNJK, P.D., 1983: The Silurian of Podolia, the guide of the excursion. *Naukova Dumka, Kiev*: 1–222.

(accepted 3 May 1991)



## NOTES ON THE GEOLOGY, GEOMORPHOLOGY AND SOILS OF THE ALGONKIAN RIVULET-UPPER MAXWELL RIVER AREA, TASMANIAN WILDERNESS WORLD HERITAGE AREA

by Grant Dixon

(with three text figures)

DIXON, G., 1992 (31:x): Notes on the geology, geomorphology and soils of the Algonkian Rivulet-upper Maxwell River area, Tasmanian Wilderness World Heritage Area. *Pap. Proc. R. Soc. Tasm.* 126: 13–18. ISSN 0080–4703. 54 Marlyn Road, South Hobart, Tasmania, Australia 7004.

Dolomite, probably Precambrian, occurs throughout the Algonkian and Maxwell valleys. It has been extensively silicified in several areas. The dolomite displays only moderate dips and overlies phyllite and schist, which comprise much of the more elevated parts of the region. The phyllite and schist were deformed at least once prior to deposition of the dolomite. Karst features occur extensively in the area, but most are no longer active. There is considerable variation in soils, from acidic peats to those associated with alkaline pans. Alkaline pans are common in the area and observations suggest that, whilst a short-term phenomenon, they may be recurring features of the landscape.

**Key Words:** Precambrian dolomite, silicification, karst, alkaline pans, Tasmania.

### INTRODUCTION

The Maxwell River and Algonkian Rivulet are part of the Gordon–Franklin river system. They drain a broad valley, remote and difficult of access, west of the Prince of Wales Range. The valley is little known and thickly vegetated, with tall buttongrass heath, closed scrub and forest.

Blake (1936) noted the presence of dolomites, quartzites and schists in the area, and prepared a rudimentary geological map. Corbett & Brown (1975) noted the occurrence of “comparatively unmetamorphosed Precambrian dolomite” and “pelitic Precambrian metamorphic rocks” in the area, with “undifferentiated Precambrian metamorphic rocks” in the surrounding region.

Cantle (1979) explored several of the depressions, lakes and small caves near Algonkian Rivulet.

Recently a number of Aboriginal archaeological sites have been discovered in dolomite caves in the lower Maxwell Valley (Ranson & Harris 1986). These notes document observations made during a survey accompanying, and made possible by, an archaeological reconnaissance of the Algonkian Rivulet–upper Maxwell River area during March 1990.

The landscape is generally low and outcrop poor. Outcrop is restricted to a few bluffs (commonly concealed in thick vegetation), creek bed exposures and rare flat-lying areas of bare rock (some associated with alkaline pans). However, the presence of depressions and dolines in many areas is indicative of underlying dolomite.

### GEOLOGY

Most of the low-lying areas of the broad valley of lower Algonkian Rivulet–upper Maxwell River consist of dolomite. The higher surrounding hills and ridges comprise presumed older Precambrian rocks. A geological map of the area is shown in figure 1.

### Older Precambrian Rocks

These rocks consist of fine-grained purple and greenish phyllites (to the northwest of the area) and quartz-mica schists. A pervasive foliation is ubiquitous, and this appears to have been gently folded. However, at DN132992 a regular crenulation of this foliation was noted and complex, small-scale folds were also observed, both trending east–west.

### Massive Dolomite

This rock is a grey, massive, fine-grained, granular dolomite. Distinct jointing is irregularly developed in some areas, with two distinct subvertical joint trends (220° and 320°) noted at DN113964. Patches of grainstone occur in some outcrops, and low-angle cross bedding was observed within 0.1–0.3 m thick, more silty seams. Equivocal stromatolitic laminations occur at DP126000 and DN127964. At DN127964, the dolomite is essentially massive, but sporadic, thin (up to 10 mm), silty layers exhibit gradation with respect of dolomite content, and produce differential relief on weathered surfaces.

Dolomite was briefly examined at two locations further down the Maxwell River valley, DN094788 and DN085877. Here the dolomite is generally similar to the massive dolomite described above, with sporadic banding and rare “graded” silty beds. It dips very slightly south or southeast.

### Bedded Dolomite

This rock is similar to the massive dolomite, but distinct banding, which is probably bedding, is apparent in weathered outcrop. The banding seems to reflect variation in silica content, with layers almost graded in places and variations in relief on weathered surfaces. At DP122001 thin (about 10 mm) layers are slightly disrupted (soft sediment deformation?). The contact with the massive dolomite is probably gradational.

### Dolomitic Siltstone

This rock outcrops extremely poorly and, where exposed, is very weathered. It appears to comprise several of the low ridges on or near the Algonkian–Maxwell watershed.

### Quaternary Gravels

Extensive lowland areas are mantled with surficial deposits of variable thickness up to at least 0.5 m, are well exposed in creek sections and consist of poorly sorted quartzitic and quartz gravels in a sandy or (less commonly) clayey sand matrix. The provenance of the clasts appears to be both the surrounding ranges and the secondary quartz in the dolomites (see below).

### Silicification of the Dolomite

The massive dolomite is silicified in several areas, but the degree can vary considerably, even within a given locality. Quartz occurs as segregations and veins within the dolomite. The quartz fills distinct “fractures”, rarely with any consistent orientation, resulting in a “breccia” or “jigsaw” appearance of the rock. The fracture veins are separated by as little as a few centimetres, up to about 0.5 m. The quartz is milky and generally fine-grained, and may be banded or zoned parallel to the vein walls, suggesting distinct phases to deposition accompanying fracture opening. Quartz was also observed, albeit very rarely, as small (2–3 mm) crystals in vugs in the dolomite. Silicification of the dolomite is pervasive outwards from the veins.

The quartz veining forms an irregular boxwork in the dolomite. This is often spectacularly displayed in the roofs of overhangs and small caves, where the intervening carbonate has weathered out.

Similar occurrences of quartz in dolomite are observed in the Weld Valley–Mt Weld area in southern Tasmania and near Corinna in northwestern Tasmania. In the former case Calver (1989) has suggested they may be remnants of an ancient (Tertiary?) silcrete. Fluid inclusion study of quartz from this area indicates low temperatures of deposition (C.R. Calver, pers. comm.). Silicified dolomite with veining and textures similar to the Algonkian Rivulet area has been described by Piasczyk (1989) from near Corinna. He considered silicification was produced by a low temperature (<200°C) fluid probably during late Proterozoic metamorphism.

## STRUCTURAL RELATIONSHIPS

The dolomite strikes generally NE–SW and dips moderately to the southeast in the northern (lower Algonkian) part of the area, and to the northwest or is subhorizontal in the southern (upper Maxwell) part of the area. It is gently folded, but this is rarely apparent in outcrop. Where hinges are observed (e.g. DP126000), very open folds plunge gently southeast. The dolomite appears unstrained, although jointing has been noted.

Dolomite overlies the older Precambrian rocks with low-angle unconformity, exposed at DP122004 in the bed of Algonkian Rivulet. No conglomerate, breccia or shearing is evident at the contact, although there is a small “disturbed”

area with steeper dips in the phyllite 50 m to the north.

As noted previously, the older Precambrian rocks have a pervasive foliation, which has itself been folded to some degree. An east–west trending crenulation of this foliation occurs below the unconformity at DP122004. However, the crenulation is not apparent in the overlying, more competent, bedded dolomite.

No conclusive evidence of facing was observed in the dolomites, but possible grading in some beds near DP123002 suggests they are not overturned. Given the moderate dips, gentle folding and relationship to the older Precambrian rocks, the sequence is unlikely to be overturned.

## DISCUSSION OF GEOLOGY

The unconformable relationship of the dolomite to presumed older Precambrian rocks, low tectonometamorphic grade and comparison with similar rocks elsewhere in Tasmania suggest a late Precambrian age for the dolomitic rocks of the Algonkian–Maxwell valleys.

The lithology and general stratigraphic setting of the Algonkian–Maxwell dolomites suggest correlation with parts of the Weld River Group (Calver 1989), the Jane Dolomite, described from 30 km north (Spry & Zimmerman 1959) and the Success Creek Group and correlates in northwestern Tasmania (Williams 1976). These latter sequences have all been correlated at one time or another (Calver 1989, and others). However, unlike the Weld River Group, the Algonkian–Maxwell dolomites unconformably overlie rocks which have experienced at least one cleavage-forming event (the Penguin Orogeny?), and so are similar to the Jane Dolomite (as inferred by Spry & Zimmerman 1959).

Calver (1989) suggested a diminished Penguin Orogeny may have affected the Tyennan region (at least the Weld Valley area), but this appears not to be the case in the Algonkian–Maxwell area.

### Karst Features

Whilst the topography of the area is relatively low-lying, many small, residual hills and small ridges rise abruptly from the lowlands to heights of up to 30 m. A few of these hills consist of older Precambrian rocks but many are dolomite. Bluffs may be developed on such ridges, in places with separated “towers”.

Such bluffs are best developed in the more silicified dolomite, in the lower Algonkian valley. It is the location of a number of small caves and shelters or overhangs (including all the Aboriginal archaeological sites discovered during this survey). Such features also appear to be, at least in part, structurally related, with both large shelters in the DP126000 area occurring in or near the hinge zone of open folds in the dolomite.

Elsewhere, karst topography consists of numerous depressions or dolines and small dry or blind valleys, with only sporadic outcrop. These may be subadjacent dolines. A larger (probably collapse) doline occurs at DP126000, surrounded by bluffs. Rudimentary rillenkarrren morphology is developed on some exposed dolomite surfaces in the lower Algonkian area. The bedded dolomite appears generally less predisposed to the formation of karst features.

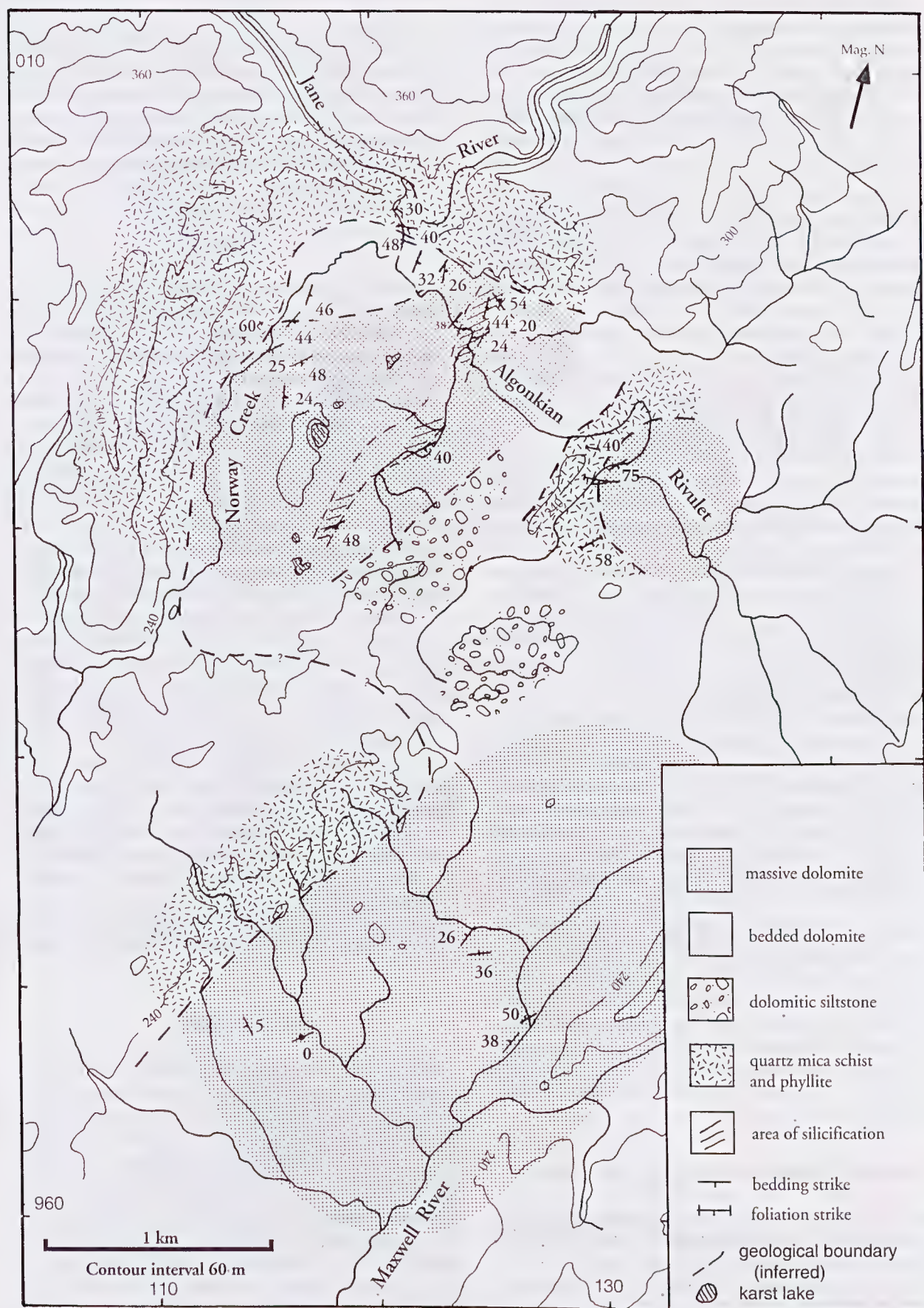


FIG. 1 — Geological map of the Algonkian-Maxiwell area.

The most significant karst features in the area are the lakes situated on the broad ridge between Algonkian Rivulet and Norway Creek indicated in figure 1. Such karst lakes are rare in Tasmania. There are three large lakes (the largest being 120 × 70 m in size) and several small ones. They occur in depressions, the northernmost one complex and uvala-like. The lakes have no apparent outlet, although the northern one (at DN121997) may experience surface drainage to the south during periods of particularly high water. However, the local vegetation suggests this is a rare occurrence. The water level of the larger lakes appears to fluctuate by about 0.5 m, but the occurrence of sphagnum around the margin of the northern lake suggests the water has been at its present low level for several years (J. Whinam, pers. comm.). The lakes appear generally shallow, with deep clayey mud deposits, although the northern one, with steep 20 m sides forming part of the depression, may have a water depth of several metres.

Pools and flooded dolines occur elsewhere in the Maxwell valley, often intriguingly located atop small hills, suggesting perched water tables, but nowhere else do they have the size or setting of the aforementioned lakes.

The northern lake lies on a line of dolines of various sizes extending northwards towards Algonkian Rivulet. Such doline trends are not uncommon, with the western fall of the ridge east of Norway Creek also partly controlled by such a feature.

Many small, usually subcircular depressions, up to 10 or 15 m in diameter, occur throughout the area. They are partly infilled by sediment, with evidence they were once water-filled, and are still occasionally inundated. They display sharp discontinuities in the vegetation, with the flat floors occupied by very simple communities including mosses and, in one case, a rare sphagnum.

The lakes and infilled dolines in the area may have considerable potential for palynological studies.

In the upper Maxwell valley, where the dolomite is less silicified and generally flatter-lying, the karst features have a different character. At DN126967 a stream cave more than 30 m in length, with a partly-phreatic side passage also some 30 m in length, has developed. The stream sinks in a large collapse doline and flows completely through a small hill. Rudimentary decoration and clastic "microspeleothems" occur.

Well-developed rillenkarren occurs on outcrops in an alkaline pan at DN127964 and on bluffs in the DN113964 area. Grikes and small fissure caves also occur in the DN113964 area, development of the former having been controlled by two major sub-vertical joint orientations in the dolomite. The presence of small "foot caves" or notches on the southern side of the bluffs at DN113964 suggest higher water levels and/or an alternative course of the adjacent stream in the past.

### Drainage Pattern and Geomorphic History

The reconnaissance nature of the investigations described herein preclude detailed discussion of the geomorphic history of the area, but some general conclusions can be made.

The generally orthogonal drainage pattern, with directions apparently similar to major joint orientations in the dolomite (particularly in the upper Maxwell valley), the observed structural control of many of the karst features and the presence of numerous dolomite residuals suggest that

drainage development has probably been controlled by the jointing.

Given the inactive nature of most of the karst features, that dolomite generally occupies the lower parts of the landscape with numerous residuals and that the present drainage is largely surficial, the area is considered to be in "old age" in terms of its geomorphic history. Much karst development probably occurred during Late Pleistocene times, or earlier, with more recent deposition of much of the surficial gravels.

### Soils

Soils in the lower Maxwell valley have been described by Tarydas (1978), who noted considerable variation in soils and substrates. He noted organic soils (peats), almost entirely fibrous, as the dominant soil, developed over sandy, gravelly and loamy material.

In the Algonkian-Maxwell area there is considerable variation in soils, due mainly to the dolomite bedrock and karst-related environments. The forested areas of older Precambrian bedrock have shallow organic horizons over clay loams, as noted by Pemberton (1989) for his South-West land system which includes the surrounding ranges. Skeletal, gravelly soils occur on some ridge crests.

Brown fibrous peat is common throughout the area, occurring beneath both buttongrass heath and closed teatree scrub (the latter with a thick litter layer). In most areas it overlies, or grades into, fine siliceous gravels. Whilst soil pHs (measured in the field with an Inoculo CSIRO test kit) of 3.5–4.5, typical of other parts of southwestern Tasmania (M. Pemberton, pers. comm.), do occur in the area, pHs of the peats are often around 5.5. This presumably reflects the carbonate bedrock, or at least drainage therefrom. Dark muck peats occur in poorly drained areas.

Other soils noted in the area include alluvial sandy loam (pH 5.5–6) occurring along Norway Creek, sandy clay loam (pH 4–4.5) and pale-brown sand (pH 6.5) noted in two infilled dolines, black clayey ooze (pH 6) and dark-brown clay (pH 5) occurring adjacent to and beneath the karst lakes, and thin sandy loam (pH 6 to 6.5) occurring on dolomitic siltstone.

Soils on the alkaline pans (see below) consist of thin, cream-coloured, in places clayey, sand with pH ranging from 7 to 9.

### Alkaline Pans

Brown *et al.* (1982) described alkaline pans from the Hardwood River valley. Such pans are also known to occur in the Maxwell and Giblin River valleys and Sandfly Creek area, near Mt Anne (Jarman *et al.*, 1988). Pans in the Giblin and Hardwood valleys are related to limestone bedrock and those in the Maxwell valley and Sandfly Creek areas to dolomite bedrock. Jarman *et al.* (1988) described two broad classes of vegetation characteristic of pans and suggested that the botanical differences may be related to bedrock type. However, the two types are not always mutually exclusive (*op. cit.*), as exemplified by some alkaline pans in the upper Maxwell valley (L. Gilfedder, pers. comm.).

The alkaline pans of the Algonkian-Maxwell area are interspersed among more acidic peats, as elsewhere. They are particularly common within an area of some 2 km<sup>2</sup> of

the upper Maxwell valley, south from DN127964, and range in size from a few square metres to more than 800 m<sup>2</sup>. The pale pans with their sparse, open vegetation contrast sharply with the surrounding buttongrass-heath vegetation, as described by Brown *et al.* (1982), and so are conspicuous, particularly on aerial photographs.

A feature of all the alkaline pans observed is their location at the foot of steep slopes. In the case of the pan at DN113963, steep slopes occur on all sides of the pan. With the exception of the pan-like area at DN123995 (located on a small creek line) all pans observed are situated immediately adjacent to main drainage lines. Their surfaces are wet and they experience periodic sheet wash, in addition to seepage from the adjacent slopes — often from several directions in the larger, more complexly-shaped pans. The pans occur in areas of dolomite bedrock, with low (< 0.3 m) outcrops in the floor of the larger, better developed pans. Brown *et al.* (1982) noted reprecipitated carbonate (as concretions on pebbles) in alkaline pans in the Hardwood valley, but no such features were noted on the Algonkian–Maxwell pans. This may be a function of the dolomitic, compared to limestone, bedrock.

The soils of several alkaline pans, or pan-like areas, were examined in the field. An Inoculo CSIRO test kit was used to determine pH.

The pan at DN 127964 is large (> 800 m<sup>2</sup>), irregular in shape and has numerous areas of exposed dolomite bedrock. Soil descriptions in a transect across a typical edge to this pan are given in figure 2. The spectacular increase in soil pH (4 units over 0.3 m) at the edge of the pan is of particular note.

In the major inflow region of the pan described in figure 2 (subject to seepage and periodic sheet wash) is a delta-like area with more than 0.2 m depth of sandy siliceous gravels (pH about 6). There is an apparent size sorting to smaller pebbles farther out into the pan. These pebbles are probably reworked from the surrounding surficial deposits.

The pan at DN113963 in the upper Maxwell valley is about 30 m across and surrounded by steep slopes. Dolomite bedrock is not exposed, and occurs at more than 0.1 m depth beneath the cream-coloured clayey sand of the pan. There is a distinct surface-water flow from the northwest of the pan, with siliceous gravels concentrated in the south-eastern corner. Soil pH (at about 50 mm depth) is 8–8.5 in the pan centre, 7.5–8 at the edge, and 7–7.5 near the inflow area.

Two pan-like areas occur north of an east–west trending dolomite ridge in the DN124995 area. These pans are wetter than those described above, contain small mounds with vegetation more typical of the surrounding peats and soil pH is somewhat less alkaline. They are incipient pans, possibly undergoing a process of invasion. Brown *et al.* (1982) suggested alkaline pans are a short-term (albeit up to several hundred years) feature of the landscape, which are slowly infilled by sedimentation and encroached upon by the surrounding peat.

The “pan” at DN124995 (fig. 3) is about 40 × 10 m in size and slopes around 4° to the east. Periodic surface flow occurs downslope, and subsurface seepage occurs from the dolomite ridge to the south. (At the time of observation the local water table was at 0.05 m depth at F and 0.4 m depth at B.)

About 100 m up-valley to the west of the DN124995 (figure 3) “pan” a pan-like area is located on a drainage line. Cream-coloured sand (pH 7) occurs in the centre of the “pan”, brown fibrous sand (pH 5.5–6) at the edge, and dark brown peaty clay loam (pH 4.5) in the adjacent area (all within a distance of 2 m). An algal mat-covered area of the pan has sand with pH 6.5.

The occurrence of peat beneath the sand of the pan at DN124995 and the absence of dolomite bedrock at shallow depth suggests that the reasons for the formation and existence of this “pan” may be somewhat different from those of others in the upper Maxwell area, described previously. Brown *et al.* (1982) suggested pan formation may be initiated by severe peat-burning fires. In the case of the DN124995 pan, such a fire may have not completely destroyed the now sub-pan peat but promoted alkaline run-off, erosion on slopes and sedimentation from the surrounding area.

Outcrops of dolomite in the large alkaline pan at DN127964 display two or three “steps”, apparently a result of dissolution, up to 0.2 m above the present pan surface. A one metre high dolomite outcrop protruding from another pan several hundred metres to the southwest shows spectacular undercutting (of up to 0.2 m) near its base, also apparently a result of dissolution. As noted previously, Brown *et al.* (1982) considered alkaline pans to be relatively short-term phenomena in the landscape. However, these dissolution features suggest the pans may also be repeated (in time) features of the landscape, dissolution of the dolomite occurring during previous pan “lives”, when they and/or the encroaching peat were at a slightly different level.

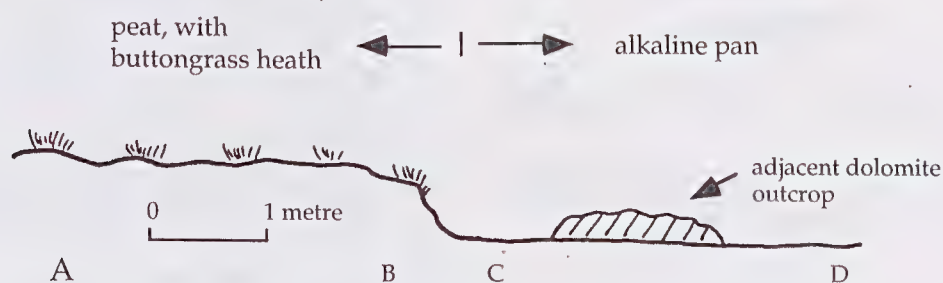
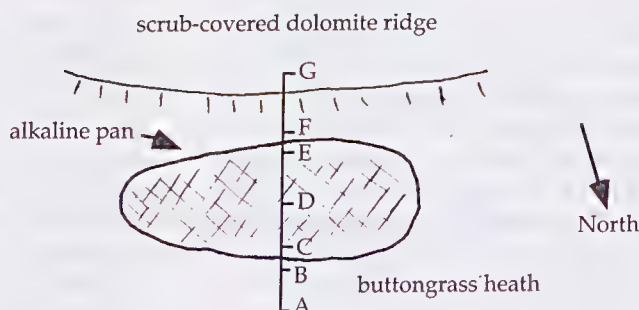


FIG. 2 — Transect across margin of alkaline pan, DN127964. (A) 0.3 m dark-brown, fibrous peat overlying less fibrous, rather organic-rich clay loam, pH 3.5–4. (B) 0.12 m dark-brown, organic-rich clay loam/peat overlying clay loam with coarse (> 10 mm) quartz gravel, pH 4.5 (50 mm depth), 3.5–4 (0.1 m depth). (C) 5 cm grey-cream-coloured sand on dolomite bedrock, pH 8.5–9. (D) 30 mm cream-coloured clayey sand on dolomite bedrock, numerous flat siliceous pebbles, pH 8.5–9.

Plan (sketch), showing location of transect below



Cross section (sketch)

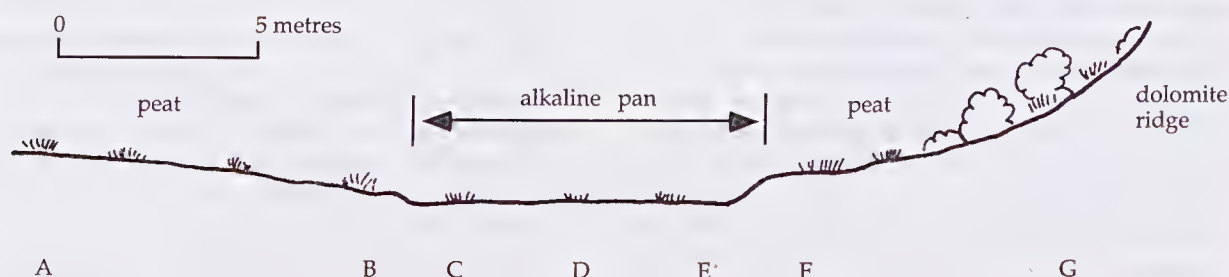


Fig. 3.—Alkaline pan at DN124995. (A) 0.4 m dark-brown, peaty clay loam with sporadic siliceous gravel, overlying fine siliceous gravels, pH 4 (at 50 mm and 0.3 m). (B) Dark-brown, mucky fibrous peat with minor siliceous gravel, becoming sandy at 0.45–0.5 m depth, pH 4.5 at 50 mm, 5.5–6 at 0.45 m. (C) 60 mm cream-coloured sand overlying grey-brown, fibrous, peaty sand, pH 6.5–7. (D) 0.1 m cream-coloured sand overlying grey, fibrous sandy peat, pH 7 at 50 mm. (E) Sandy clay, grading to clay over 20 cm, pH 5.5–6. (F) Very dark-brown, mucky fibrous peat with clay, pH 4.5. (G) Brown, fibrous clay loam, becoming less fibrous with depth, pH 5 at 50–100 mm, 4 at 0.5 m depth.

Therefore, with time, pans may recur in certain locations (perhaps initiated by severe fires, as Brown *et al.* [1982] suggested), and it follows that their specific location is probably related to local topographic, hydrologic and/or geologic factors.

## ACKNOWLEDGMENTS

I wish to thank the Archaeology section, Department of Parks, Wildlife and Heritage, and particularly Brian Prince, for the opportunity to visit the area. M. Pemberton, M.R.Banks, E.Williams and C.R.Calver are thanked for useful suggestions.

## REFERENCES

- BLAKE, F., 1936: Report on district between Jane River and Prince of Wales Range. Department of Mines, Geol. Survey Typed Reports.
- BROWN, M.J., CROWDEN R.K & JARMAN, S. J., 1982: Vegetation of an alkaline pan–acidic peat mosaic in the Hardwood River Valley, Tasmania. *Aust.J.Ecology* 7: 3–12.
- CALVER, C. R., 1989: The Weld River Group — a major upper Precambrian dolomite sequence in southern Tasmania. *Pap. Proc. R. Soc. Tasm.* 123: 43–54.
- CANTLE, I., 1979: Jane Rivering. *Southern Caver* 9: 9–10.
- CORBETT, K. D. & BROWN, A. V., 1975: *Queenstown, Tasmania*. Tasm. Dep. Mines 1:250 000 Geol. Atlas Series, sheet SK55/S.
- JARMAN, S. J., KANTVILAS, G. & BROWN, M. J., 1988: Buttongrass moorland in Tasmania. *Tas. Forest Research Council, Res. Rep.* 2: 50–51.
- PIASZCZYK, D., 1989: The characterisation and genesis of the silica flour deposits at Corinna. Unpubl. B.Sc.(Hons.) thesis, Geol. Dep., Univ. of Tasm.
- PEMBERTON, M., 1989: *LAND SYSTEMS OF TASMANIA REGION 7—SOUTH WEST*. Department of Agriculture, Tasmania.
- RANSON, D. & HARRIS, S., 1986: Maxwell River archaeological survey. Tasmanian NPWS. Report of survey, National Estate Grant 84/85, No. 8.
- SPRY, A. & ZIMMERMAN, D., 1959: The Precambrian rocks of Tasmania, part IV — the Mt. Mullers area. *Pap. Proc. R. Soc. Tasm.* 93: 1–9.
- TARVYDAS, R. K., 1978: *LOWER GORDON RIVER SCIENTIFIC SURVEY—SOILS*. Hydro-Electric Commission, Tasmania.
- WILLIAMS, E., 1976: *Explanatory notes for the 1:500 000 structural map of pre-Carboniferous rocks of Tasmania: Tasman Fold Belt system in Tasmania*. Tasmanian Dept Mines.

(accepted 3 May 1991)

## DEVONIAN LAMPROPHYRES FROM MT LYELL, WESTERN TASMANIA

by P.W. Baillie and F.L. Sutherland

(with two tables and two text-figures)

BAILLIE, P.W. & SUTHERLAND F.L., 1992 (31:x) Devonian lamprophyres from Mt Lyell, western Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 19–22. ISSN 0080–4703. Department of Mines, PO Box 56, Rosny Park, Hobart, Tasmania, Australia 7018 (PWB); and Division of Mineralogy, Australian Museum, PO Box A285, Sydney South, NSW, Australia 2000 (FLS).

Mica concentrated from a post-cleavage lamprophyre occurring at the Prince Lyell Mine, Queenstown, has yielded a K-Ar age of  $363 \pm 3$  Ma (latest Devonian). This minette is the first confirmed evidence of Devonian potassic lamprophyric activity from Tasmania and places an upper constraint on Devonian ductile deformation in western Tasmania.

**Key Words:** lamprophyre, geochronology, Devonian, Mt Lyell, Tasmania.

### INTRODUCTION

Tasmania consists of a basement orogen (the southern extremity of the Tasman Fold Belt) overlain by relatively flat-lying Upper Carboniferous–Upper Triassic glacio-marine and fresh water successions, all of which have been intruded by thick sheets of mid-Jurassic dolerite (Burrett & Martin 1989).

Unsheared lamprophyre dykes intrude the Jurassic and older rocks at numerous localities throughout Tasmania (Sutherland & Corbett 1974). Previous dating of these post-orogenic lamprophyres of shoshonitic affinity has indicated episodes related to mid-Cretaceous syenitic or dioritic activity (Cygnnet – McDougall & Leggo 1965; Cape Portland – McDougall & Green 1982), or similar potassic alkaline activity of late Jurassic–early Cretaceous age (King Island – McDougall & Leggo 1965).

However, the extent of the Cretaceous alkaline magmatism was uncertain, particularly in respect to lamprophyric bodies intruding the Palaeozoic–Precambrian basement rocks of western Tasmania (Sutherland & Corbett 1974). To help resolve the question, lamprophyre dykes exposed in the Prince Lyell mine, Queenstown, were sampled for age determination.

### DYKE RELATIONSHIPS

Lamprophyre dykes intruding both mineralised and unmineralised Mt Read Volcanics rocks in the Queenstown area (Solomon 1964, Corbett 1981) lie within a belt (fig. 1) that extends from north of Queenstown to south of Low Rocky Point and east to the Florentine Valley (Sutherland & Corbett 1974).

The Queenstown lamprophyres all consist of narrow tabular bodies, generally less than 2 m in width, which are unmineralised and uncleaved. In underground exposures at the Mt Lyell mine, it can be clearly observed that dyke intrusion was controlled by the strongly-developed pre-existing (presumably mid-Devonian) cleavage. Figure 2 is traced from a photograph taken in the now mined-out 30-Series stoping block and shows that some faulting locally accompanied the dilational intrusion.

### DYKE CHEMISTRY AND PETROGRAPHY

In all surface and most sub-surface outcrops the lamprophyres are strongly weathered or altered. The freshest material available was excavated during construction of the Prince Lyell No. 1 Shaft (grid reference 55GCP825426).

The rock selected for dating (Geological Survey Tasmania specimen 101698) is a minette, porphyritic in texture and comprising 25–30% scattered euhedral to subhedral phenocrysts and glomeroporphyritic clusters of altered olivine, dark mica, clinopyroxene and opaques. Petrographically, two size ranges make up the phenocryst fraction; coarser crystals between 0.8 and 5.0 mm and smaller microphenocrysts.

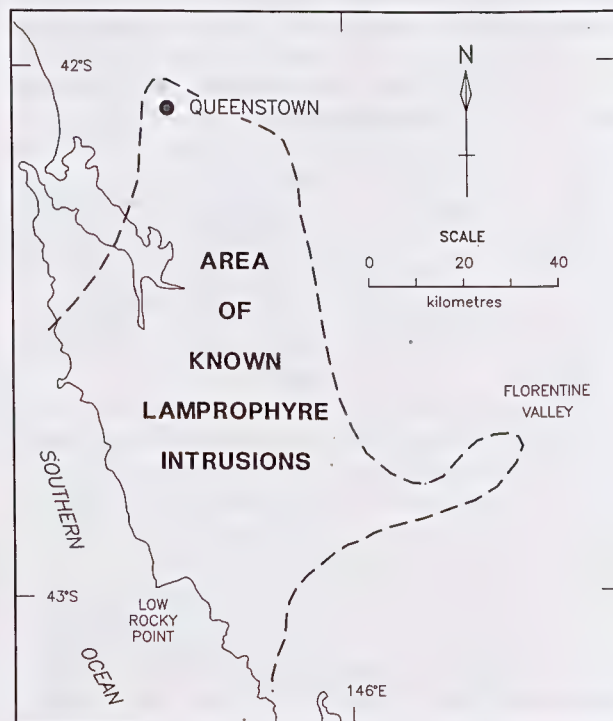


Fig. 1 — Locality map of western Tasmania showing known distribution of lamprophyre intrusions (after Sutherland & Corbett 1974).

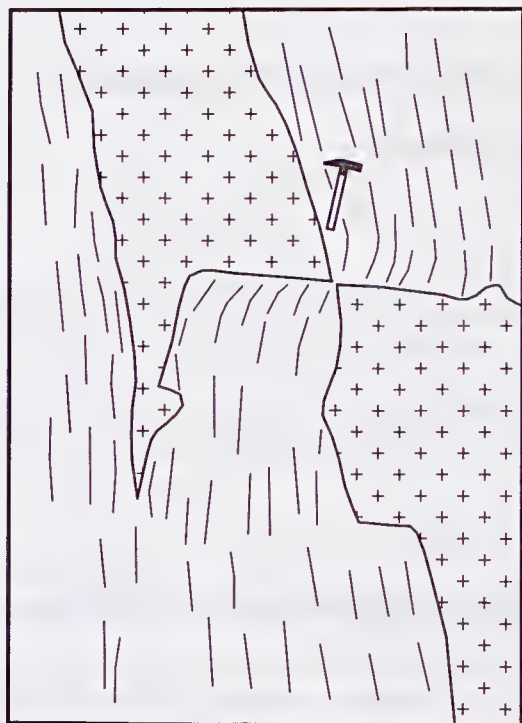


Fig. 2 — Outcrop in 30-series stopes, Prince Lyell mine, showing relationships between lamprophyre intrusion and pre-existing tectonic cleavage. Drawing traced from a photograph, geological hammer for scale.

Olivine comprises about 35% of the phenocrysts and is now composed of a talc-like mineral intergrown with carbonate (magnesite?), some minor chlorite and remnant small inclusions of red-brown spinel (chromite?). The mica (32%) is strongly pleochroic, mid-brown to straw coloured biotite-phlogopite; clinopyroxene (25%) is colourless with pale green margins; opaque oxides are also present (8%). The extremely fine-grained groundmass is largely altered and consists of subradiating aggregates of ?K-feldspar  $\pm$  ?nepheline, carbonate, and small aggregates of the biotite, opaque oxides and clinopyroxene.

Electron microprobe analyses of the main mineral phases (table 1) gave mica compositions ranging from Ti phlogopite to Ti biotite ( $\text{Mg}_{72}\text{Fe}_{28}$  to  $\text{Mg}_{60}\text{Fe}_{39}\text{Ca}_1$ ), pyroxene compositions ranging from diopside into augite ( $\text{Ca}_{45-47}\text{Mg}_{42-46}\text{Fe}_{9-11}$ ) and feldspar compositions in the sanidine range ( $\text{K}_{74-80}\text{Na}_{17-20}\text{Ca}_6$ ). The opaque oxides were mostly Ti magnetite and rarer ulvöspinel.

An analysis (table 2) shows the potassic character and high Ba, Rb, Sr typical of such mica-bearing rocks, although the Ba is also commonly carried in K-feldspar (Nemec 1987). This analysis is similar to the other minettes analysed from the Queenstown area (Solomon 1964), which are hypersthene  $\pm$  olivine  $\pm$  quartz normative rocks.

The relatively low silica and high magnesia ( $\text{MgO}$  13.8 wt%;  $\text{Mg}/(\text{Mg}+\text{Fe}^{2+})$  0.81), with high compatible trace elements such as Cr and Ni and low incompatible elements such as Zr, suggests a primitive lamprophyre ( $\text{SiO}_2 < 60\%$ ; mole%  $\text{Mg}/(\text{Mg}+\text{Fe}) > 60$ ;  $\text{Cr} > 200$  ppm;  $\text{Ni} > 75$  ppm; Rock *et al.* 1988). The lamprophyre is difficult to classify within the four main groups, being slightly richer in  $\text{MgO}$  than the limit for calcalkaline lamprophyres, but like them shows a typical low Nb content (Rock 1987). The  $\text{SiO}_2$  is too high for the ultramafic lamprophyres,  $\text{K}_2\text{O}$  too low for

most lamproites and  $\text{K}_2\text{O}/\text{Na}_2\text{O}$  (4.0) too high for most alkaline lamprophyres. More detailed assignment will require specific chemistry of the mineral phases and more extensive trace element data to compare with that documented for other lamprophyres.

## GEOCHRONOLOGY

A sample of the rock was crushed and a biotite concentrate obtained by magnetic separation. Standard techniques were used to determine the potassium content in duplicate and for the extraction and isotopic analysis of the argon.

Analyses and calculated age are:

|                                                      |             |
|------------------------------------------------------|-------------|
| % K                                                  | 6.80        |
| $^{40}\text{Ar}^* (\times 10^{-11} \text{ moles/g})$ | 47.433      |
| $\text{Ar}^*/^{40}\text{Ar}_{\text{total}}$          | 0.981       |
| Age ( $\times 10^6$ years)                           | $363 \pm 3$ |

\* Denotes radiogenic Ar.

Constants used:

|                                                             |
|-------------------------------------------------------------|
| $^{40}\text{K} = 0.01167 \text{ atom\%}$                    |
| $\lambda_{\beta} = 4.962 \times 10^{-10} \text{ y}^{-1}$    |
| $\lambda_{\epsilon} = 0.581 \times 10^{-10} \text{ y}^{-1}$ |

## DISCUSSION

This paper documents the first recorded Devonian K-rich lamprophyric activity from Tasmania. Dolerites of possible Early Devonian age are present in the Que River region of northwestern Tasmania (Corbett & Komysan 1989), but these rocks are sodic and tholeiitic in character.

Using the time scale of Harland *et al.* (1990) the lamprophyre is latest Devonian (late-Famennian) in age, near the older end of the spectrum of granitoid ages in western Tasmania which range from  $367 \pm 10$  to  $319 \pm 10$  Ma (McClenaghan *et al.* 1989). The mica-bearing lamprophyric activity seems to precede intrusion of the nearest granitic batholith, over 40 km away at Heemskirk (331–362 Ma, maximum range of Rb-Sr and K-Ar ages), and may represent a similar situation to lamprophyric dyke swarms in Britain (Rock *et al.* 1988). There mica-bearing lamprophyres are less closely associated with granites than amphibole lamprophyres, and were related to generation at higher pressures (26–27 kb) at depths greater than 80–100 km where  $\text{CO}_2$  exercises greater control than  $\text{H}_2\text{O}$  over melting of mantle sources. Although the primitive character of the Mt Lyell minettes initially suggests a relatively deep source, perhaps partial melting of a Large Ion Lithophile Element-enriched mantle, the role of crustal modifications in such melts is a critical aspect (Rock 1980).

The Mt Lyell dyke age shows that at least some of the western Tasmanian lamprophyres are Devonian. The age places an upper constraint on Devonian ("Tabberabberan") ductile deformation in western Tasmania, consistent with the presence of late Middle Devonian spores (*optivus-triangularis* spore assemblage zone, latest Givetian, about 375 Ma) in nonfolded cave deposits occurring within folded Ordovician limestone at Eugenana, near Devonport in northern Tasmania (Burns 1964, McGregor & Playford in press).

Table 1  
Representative mineral analyses, Mt Lyell minette

| Mineral analysis               | Ti phlogopite (large) | Ti biotite (small) | Diopside (phenocrysts) | Sanidine (g/mass) |
|--------------------------------|-----------------------|--------------------|------------------------|-------------------|
| SiO <sub>2</sub>               | 37.30                 | 35.39              | 52.09                  | 64.74             |
| TiO <sub>2</sub>               | 5.12                  | 5.62               | 0.50                   | 0.00              |
| Al <sub>2</sub> O <sub>3</sub> | 15.00                 | 15.46              | 1.85                   | 19.01             |
| FeO (total)                    | 11.87                 | 16.08              | 5.75                   | 0.38              |
| MnO                            | 0.00                  | 0.00               | 0.00                   | 0.00              |
| MgO                            | 17.22                 | 13.76              | 16.53                  | 0.00              |
| CaO                            | 0.00                  | 0.35               | 22.83                  | 1.32              |
| Na <sub>2</sub> O              | 0.37                  | 0.63               | 0.00                   | 2.04              |
| K <sub>2</sub> O               | 9.39                  | 8.82               | 0.00                   | 13.18             |
| Total                          | 96.27                 | 96.30              | 100.55                 | 100.67            |
| Si <sup>4+</sup>               | 5.9386                | 5.7900             | 1.9411                 | 11.8243           |
| Ti <sup>4+</sup>               | 0.6132                | 0.6871             | 0.0136                 | 0.0000            |
| Al <sup>3+</sup>               | 2.8106                | 2.9606             | 0.0794                 | 4.0873            |
| Fe <sup>2+</sup>               | 1.5802                | 2.1878             | 0.1759                 | 0.0582            |
| Mn <sup>2+</sup>               | 0.0000                | 0.0000             | 0.0000                 | 0.0000            |
| Mg <sup>2+</sup>               | 4.0865                | 3.3381             | 0.9011                 | 0.0000            |
| Ca <sup>2+</sup>               | 0.0000                | 0.0607             | 0.8942                 | 0.2592            |
| Na <sup>+</sup>                | 0.1128                | 0.1975             | 0.0000                 | 0.7229            |
| K <sup>+</sup>                 | 1.9070                | 1.8305             | 0.0000                 | 3.0700            |
|                                | 17.0489               | 17.0523            | 4.0053                 | 20.0219           |
|                                | Fe 27.9               | Fe 39.2            | Fe 8.9                 | Ca 6.3            |
|                                | Mg 72.1               | Mg 59.8            | Mg 45.7                | Na 17.8           |
|                                | Ca 0.0                | Ca 1.1             | Ca 45.4                | K 75.8            |

Analyst B.J. Barron, using an automated ETEC electron microprobe, Macquarie University, NSW. Cation contents are based on 24 oxygens (mica), 6 oxygens (pyroxene) and 32 oxygens (feldspar) respectively.

Table 2  
Whole-rock chemical analysis and CIPW norms, minette\* from  
Prince Lyell mine shaft†

| Oxide                          | %     | Trace element | g/t  | CIPW Norm (anhydrous)                     |      |
|--------------------------------|-------|---------------|------|-------------------------------------------|------|
| SiO <sub>2</sub>               | 48.14 | Ba            | 2600 | Fe <sub>2</sub> O <sub>3</sub> /FeO ratio | 0.30 |
| Al <sub>2</sub> O <sub>3</sub> | 10.94 | Ni            | 460  | Or                                        | 22.1 |
| Fe <sub>2</sub> O <sub>3</sub> | 2.24  | Pb            | 45   | Ab                                        | 7.8  |
| FeO                            | 5.69  | As            | 30   | An                                        | 15.9 |
| TiO <sub>2</sub>               | 0.89  | Bi            | b.d. | Di                                        | 6.9  |
| MnO                            | 0.19  | Ga            | 13   | Hy                                        | 28.2 |
| CaO                            | 7.47  | Zn            | 79   | Ol                                        | 9.3  |
| MgO                            | 13.80 | Cu            | 78   | Mt                                        | 2.8  |
| K <sub>2</sub> O               | 3.59  | Co            | 45   | Il                                        | 1.8  |
| Na <sub>2</sub> O              | 0.89  | Sr            | 320  | Py                                        | 0.1  |
| P <sub>2</sub> O <sub>5</sub>  | 0.34  | U             | 5    | Ap                                        | 0.9  |
| SO <sub>3</sub>                | 0.17  | Rb            | 130  | Cc                                        | 4.2  |
| CO <sub>2</sub>                | 1.78  | Y             | 28   |                                           |      |
| +H <sub>2</sub> O              | 3.62  | Zr            | 200  |                                           |      |
| Total                          | 99.75 | Nb            | 10   |                                           |      |
|                                |       | Mo            | b.d. |                                           |      |
|                                |       | Cr            | 830  |                                           |      |
|                                |       | V             | 165  |                                           |      |
|                                |       | Sc            | 23   |                                           |      |
|                                |       | Th            | 18   |                                           |      |
|                                |       | Nd            | 46   |                                           |      |
|                                |       | Ce            | 125  |                                           |      |
|                                |       | La            | 60   |                                           |      |

\* Specimen no. 101698

† Analysis no. 851325

b.d. = below limit of detection for that particular element

## ACKNOWLEDGEMENTS

Sampling was carried out in association with Mr J.T. Carswell, former Mine Geologist, Mt Lyell Mines; mineral separation was performed by Dr D.C. Green, former Petrologist, Tasmania Department of Mines. Underground access and assistance was provided by Mr B.F. Atkinson, former Mine Superintendent, Mt Lyell Mines. Chemical analyses were performed at the Department of Mines Laboratories, Launceston, and age dating by AMDEL, Adelaide. Dr B.J. Barron, Division of Earth Sciences, Australian Museum, helped with petrographic descriptions. The manuscript was improved by critical reading by Dr G.R. Green. PWB publishes with the permission of the Tasmania Department of Mines. The age dating was supported by funds from the Australian Museum Trust.

## REFERENCES

- BURNS, K.L., 1964. *Devonport, Tasmania*. Tasm. Dep. Mines 1 Mile Geol. Atlas Ser., Expl. Rep., Sheet K55-6-29.
- BURRETT, C.F. & MARTIN, E.L. (Eds), 1989. *GEOLOGY AND MINERAL RESOURCES OF TASMANIA*. *Geol. Soc. Aust. Spec. Pub.* 15: 574 pp.
- CORBETT, K.D., 1981. The Mt Read Volcanics and associated rocks in the Lake Margaret road — East Queen River area, Queenstown. Dep. Mines unpubl. rep. 1981/53.
- CORBETT, K.D. & KOMYSHAN, P., 1989. Geology of the Hellyer—Mt Charter area. *Geol. Rep. Mt Read Volc. Project, Tasm.* 1.
- HARLAND, W.B., ARMSTRONG, R.L., CRAIG, L.E., COX, A.V., SMITH, A.G. & SMITH, D.G., 1990. *A GEOLOGIC TIME SCALE 1989*. Cambridge University Press, Cambridge.
- MCCLENAGHAN, M.P., COMACHO, A., HIGGINS, N.C. & REID, E.J., 1989. Mid-Palaeozoic granitoids. In Burrett, C.F. & Martin, E.L. (Eds): *GEOLOGY AND MINERAL RESOURCES OF TASMANIA*. *Geol. Soc. Aust. Spec. Publ.* 15: 253-270.
- MCDUGALL, I. & GREEN, D.C., 1982. Appendix 3 — Cretaceous K/Ar ages from north-eastern Tasmania. In McClenaghan, M.P., Turner, N.J., Baillie, P.W., Brown, A.V., Williams, P.R. & Moore, W.R.: *Geology of the Ringarooma—Boobyalla area*. *Bull. Geol. Surv. Tasm.* 61: 179-181.
- MCDUGALL, I. & LEGGO, P.J., 1965. Isotopic age determinations on granitic rocks from Tasmania. *J. Geol. Soc. Aust.* 12: 295-332.
- MCGREGOR, D.C. & PLAYFORD, G., in press. Canadian and Australian Devonian spores: zonation and correlation. *Geol. Surv. Canada Bull.*
- NEMEC, D., 1987. Barium in dyke rocks of the minette series. *Chem. Erde* 47: 117-124.
- ROCK, N.M.S., 1980. "Rare-earth and other trace element contents and the origin of minettes". A Critical Comment on a paper by Bachinski and Scott (1979). *Geochim. Cosmochim. Acta* 44: 1385-1388.
- ROCK, N.M.S., 1987. The nature and origin of lamprophyres: an overview. In Fitton, J.G. & Upton B.G.J. (Eds): *ALKALINE IGNEOUS ROCKS*. *Geol. Soc. Spec. Publ.* 30: 191-226.
- ROCK, N.M.S., GASKARTH, J.W., HENNEY, P.J. & SHAND P., 1988. Late Caledonian dyke-swarms of northern Britain: some preliminary petrogenic and tectonic implications of their province-wide distribution and chemical variation. *Can. Miner.* 26: 3-22.
- SOLOMON, M., 1964. The spilite-keratophyre association of west Tasmania and the ore deposits at Mt Lyell, Hercules and Rosebery. Unpubl. PhD thesis, University of Tasmania.
- SUTHERLAND, F.L. & CORBETT, E.B., 1974. The extent of Upper Mesozoic igneous activity in relation to lamprophyric intrusions in Tasmania. *Pap. Proc. R. Soc. Tasm.* 107: 175-190.

(accepted 9 August 1991)

## A NEW GENUS AND SPECIES OF AQUATIC CAVE-LIVING SNAIL FROM TASMANIA (MOLLUSCA: GASTROPODA: HYDROBIIIDAE)

by W.F. Ponder

(with one table, three text-figures and one plate)

PONDER, W.F., 1992 (31:x): A new genus and species of aquatic cave-living snail from Tasmania (Mollusca: Gastropoda: Hydrobiidae). *Pap. Proc. R. Soc. Tasm.* 126: 23–28. ISSN 0080–4703. Australian Museum, PO Box A285, Sydney South, NSW, Australia 2000.

A new species and genus of hydrobiid snail, *Pseudotricula eberhardi*, is described from caves at Precipitous Bluff, southwestern Tasmania. This is the first description of a subterranean mollusc from Australia.

**Key Words:** cave-living, snail, aquatic, Tasmania.

### INTRODUCTION

Although there are cave-dwelling hydrobiid snails known from many parts of the world, none have been described from Australia, although several species are known from New Zealand (Ponder 1966; Climo 1974, 1977). Recently several collections made by Stefan Eberhard in Tasmanian caves have been made available to the writer. All of the material is undescribed and most are species that are similar to, or, in some cases, the same as surface taxa. One species, however, is very unusual, being unlike any taxon known from Australasia, and is described herein.

This report forms a minor part of a survey of the hydrobiid taxa of Australia. Other work currently in preparation will deal in more detail with the relationships of this taxon.

### METHODS

Standard methods were employed to mount material for scanning electron microscope examination and for dissection (Ponder *et al.* 1989). Material was fixed in formalin in the field and then transferred to ethanol. Shells were measured using a digitising pad linked to a microcomputer, as described by Ponder *et al.* (1989). Ten of the measured specimens were then sexed after dissolving the shells with dilute hydrochloric acid. Anatomical investigation was carried out on seven of the measured specimens, using a stereoscopic microscope with the specimens being dissected on a black wax background in dilute Bouin's fluid. Material is housed in the Australian Museum, Sydney (AMS) and the Tasmanian Museum, Hobart (TM).

### TAXONOMY

#### *Pseudotricula* n. gen.

Type species

*Pseudotricula eberhardi* n.sp.

Etymology

Named for the close resemblance of the shell to the Asian genus *Neotricula* (Pomatiopsidae).

#### Diagnosis

Shell (pl.1A) broadly conical, aperture with reflected outer lip, non-umbilicate. Protoconch (pl.1C, D) paucispiral, minutely punctate. Operculum (pl.1B, F) thin, inner surface lacking white smear or pegs, with markedly eccentric nucleus. Head (fig. 1A) with rather short, bilobed snout with scattered lateral cilia; cephalic tentacles long, tapering and appear to lack well-developed ciliary bands; eyes (fig. 1A; e) small, pigmented, at outer bases of tentacles. Radula (pl.1G, H) with 2 (or rarely 3) pairs of small basal cusps on central teeth, outermost smallest. Pallial edge (fig. 1B; pe) thick, simple (i.e. no pallial tentacle). Ctenidium (fig. 1B; ct) short, confined to anterior two-thirds of cavity, with small, narrowly triangular filaments and with long, narrow efferent vessel (fig. 1B; ev) to pericardium. Osphradium (fig. 1B; os) small, oval, between posterior end and middle of ctenidium. Hypobranchial gland (fig. 1B; hg) lacking from anterior pallial roof, well developed posteriorly in narrow zone abutting rectum and also covering rectal coils. Rectum (fig. 1B; r) coiled in S-shape across posterior pallial roof; packed with oval faecal pellets. Anterior segment of rectum straight, on right side of cavity; anus (fig. 1B; a) set back slightly behind thickened part of mantle edge. Columellar muscle (fig. 1A; cm) short and broad. Glandular pallial genital tract (fig. 1B; po) in posterior part of extreme right side of cavity. Renal organ extends partly into pallial roof (fig. 1B; rg). About half of length of pericardium (fig. 1B; pc) in pallial roof. Anterior alimentary canal typical of family. Stomach short, with large anterior gastric chamber, very small posterior chamber, single digestive gland opening and lacking posterior caecum. Male genital system with prostate gland (fig. 2C; pr) about half in pallial roof, kidney-shaped, approximately circular in section, pallial part with very thin ventral wall. Pallial vas deferens (figs 2C, 3A; pvd) opening mid-ventrally from pallial prostate gland, thin, non-muscular, straight or with slight undulations. Penis (fig. 3) with simple, long, tapering distal end; medial section simple, rather narrow, with straight to undulating penial duct; base expanded, with distinct transverse folds when at rest and undulating penial duct (fig. 3; pd). Female genital system with ovary short and simple; proximal coiled oviduct (fig. 2A; pco) simple U-shape, with U inclined anteriorly, not embedded in connective tissue, probably slightly muscular, surface firm and smooth; extends back to posterior end of bursa copulatrix; short and straight (fig. 2B; dco) distal to seminal receptacle. Coiled

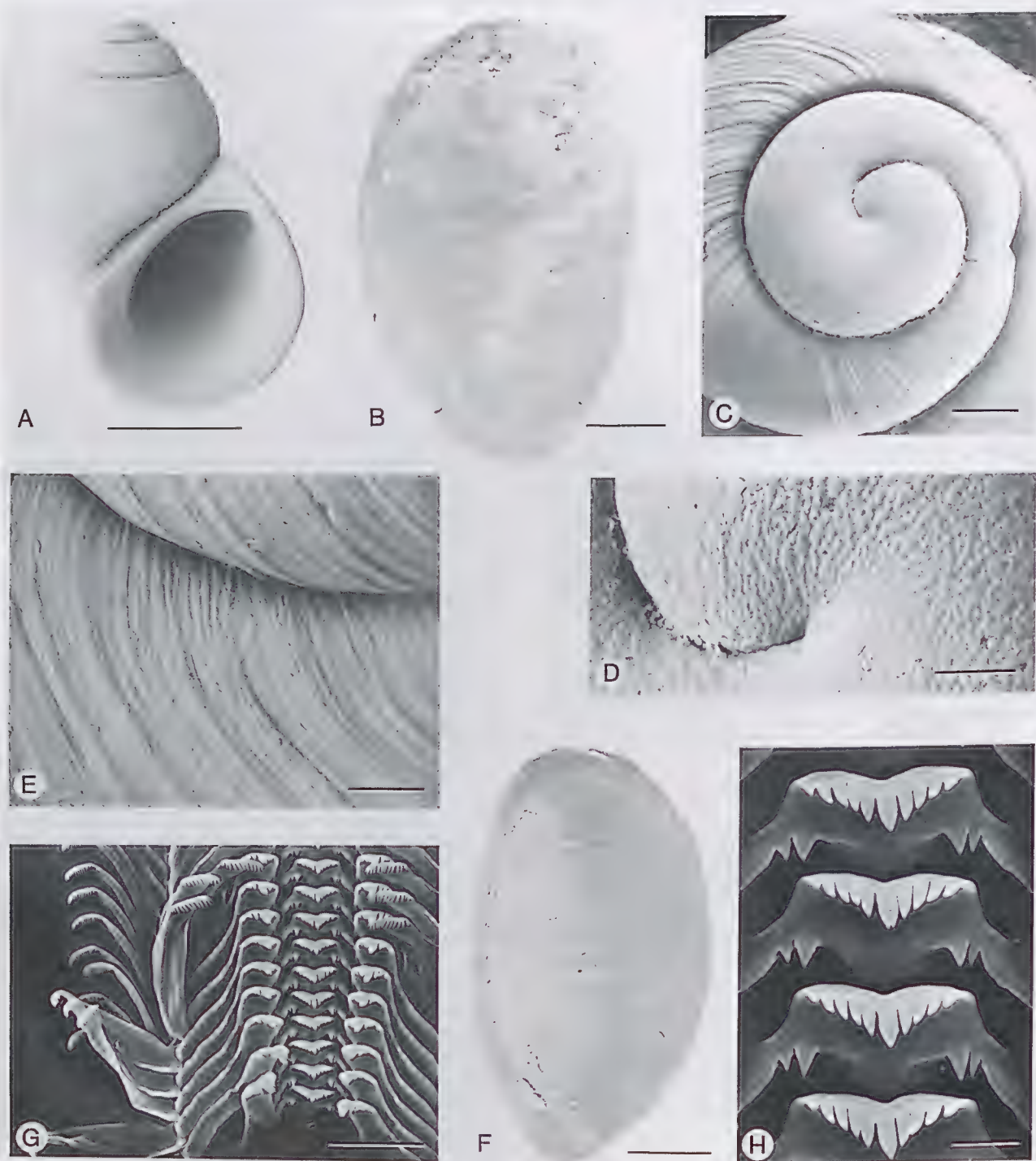


PLATE 1

(A) Shell (holotype). (B, F) Operculum (B, outer side, F, inner side). (C, D) Protoconch (D, detail of microsculpture). (E) Detail of teleoconch microsculpture. (G, H) Radula (H, detail of central teeth). Scales: (A) 1mm, (B, F) 200  $\mu$ m, (C) 100  $\mu$ m, (D, G) 30  $\mu$ m, (E) 50  $\mu$ m, (H) 5  $\mu$ m.

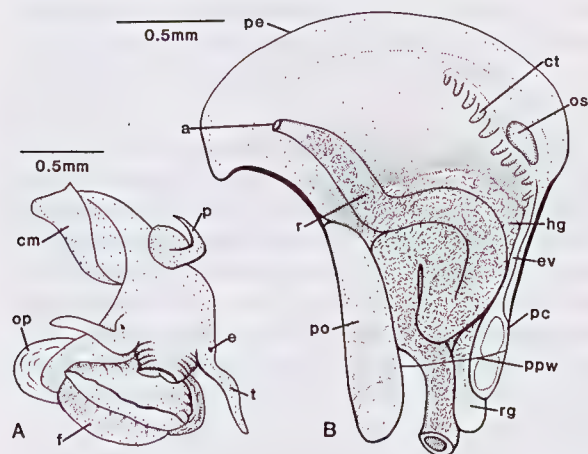


FIG. 1 — (A) Head-foot with the pallial roof and visceral coil removed. (B) Pallial roof viewed from inside.

a, anus; cm, columellar muscle; ct, ctenidium; e, eye; ev, efferent blood vessel; f, foot; hg, hypobranchial gland; op, operculum; os, osphradium; p, penis; pc, pericardium; pe, pallial edge; po, pallial oviduct; ppw, posterior pallial wall; r, rectum; rg, renal gland; t, cephalic tentacle.

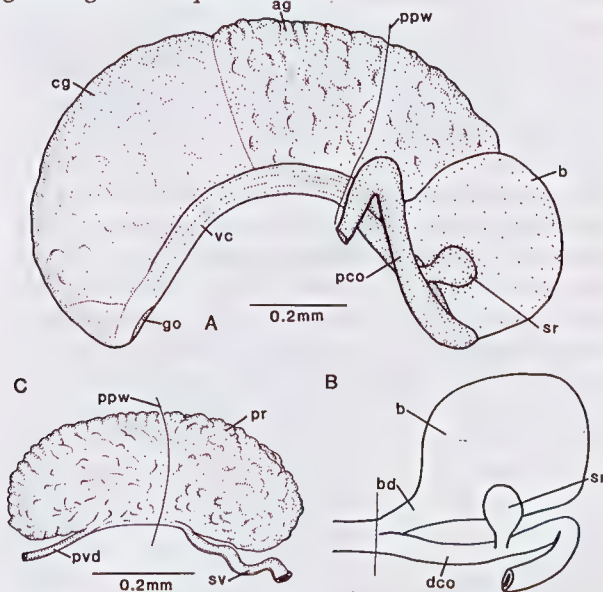


FIG. 3 — (A) Lateral view of female genital system viewed from the left side. (B) Diagram showing detail of posterior part of female genital system with the proximal part of the coiled oviduct removed. (C) Prostate gland viewed from the left side.

ag, albumen gland; b, bursa copulatrix; bd, bursal duct; cg, capsule gland; dco, distal coiled oviduct; go, genital opening; pco, proximal coiled oviduct; pr, prostate gland; ppw, posterior pallial wall; pvd, pallial vas deferens; sr, seminal receptacle; sv, seminal vesicle; vc, ventral channel. oviduct and bursal duct separate to posterior mantle wall (fig. 2B). Bursa copulatrix (fig. 2A,B; b) well behind posterior pallial wall; subglobular. Bursal duct (fig. 2B; bd) arises from antero-ventral side of bursa. Seminal receptacle (fig. 2B; sr) large, ovoid, slightly anterior to middle or at middle of left side of bursa. Two-thirds to about half of albumen gland (fig. 2A; ag) in front and half to one-third behind posterior pallial wall. Capsule gland (fig. 2A; cg) swollen, slightly wider than high, about equal to about two-thirds length of albumen gland. Ventral channel (fig. 2A; vc) simple; genital opening subterminal, small; capsule gland thin-walled in vicinity of opening. Anterior end of capsule gland well behind anus.

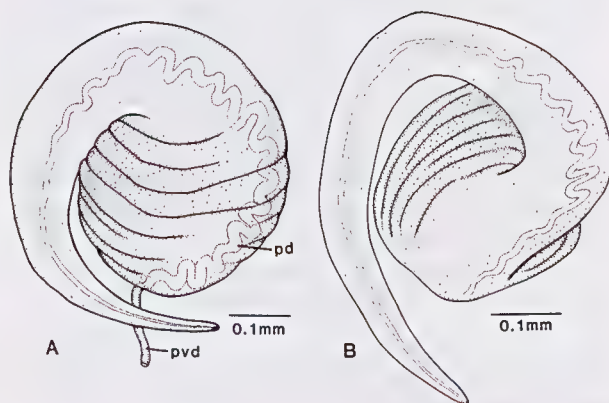


FIG. 2 — (A, B) Penes, showing variation in the length of the distal part.

pd, penial duct; pvd, pallial vas deferens.

Nervous system with cerebral ganglia separated by long commissure slightly longer than length of ganglia; supraoesophageal ganglion small, separated from right pleural ganglion by connective about 5.7 to 8 times length of supraoesophageal ganglion; suboesophageal ganglion separated from left pleural ganglion by short connective, slightly longer than suboesophageal ganglion; pedal ganglia small, separated by very short commissure.

Additional details are given in the species description.

#### Remarks

This genus is named for its superficial similarity to the Asian pomatiopsid genus *Neotricula* Davis *et al.* 1986 (see Davis *et al.* 1976, fig. 3; as *Tricula*). It differs from all pomatiopsids in having a typical hydrobiid female reproductive system (see Davis 1979 for the distinguishing characters of both families).

The new genus differs from *Beddomeia* and other genus-group names in that complex (including *Phrantela*) in having 2–3 (usually 2) pairs of denticles on the central teeth of the radula instead of one pair (Ponder *et al.*, in press), in having the outer lip of the aperture thickened and reflected, and in lacking a gastric caecum. In addition, in nearly all of the *Beddomeia*-group taxa, the pallial vas deferens opens at the anterior end of the prostate gland and the seminal receptacle is adjacent to the posterior part of the bursa copulatrix. Most of the other named genera of Australasian hydrobiids have white material (often referred to as “calcareous”, but see comment by Ponder *et al.* 1991) on the inner side of the operculum and three or more pairs of denticles on the central teeth. These genera include *Fluvidona* Iredale, 1937 (= *Angrobria* Iredale, 1943, *Rivissessor* Iredale, 1943 and *Pupiphryx* Iredale, 1943), *Posticobia* Iredale, 1943 and *Tatea* T. Woods, 1879 (Ponder *et al.* 1991) from Australia, and *Potamopyrgus* Stimpson, 1865 and allied genera from New Zealand (Climo 1974, 1977). Some genera in this group have only two pairs of denticles on the central teeth, including the New Caledonian *Hemistomia* and the Australian genera *Fonscochlea* (Ponder *et al.* 1989) and *Jardinella* (Ponder & Clark 1990, Ponder, 1991). However, all members of this

group differ from *Pseudotricula* in opercular characters (having pegs or a white smear), in not having a reflected outer lip and in the pallial vas deferens opening from the prostate gland at the posterior pallial wall, not between this wall and the anterior end of the prostate, as it does in *Pseudotricula*. Species of *Trochidrobia* (Ponder *et al.* 1989) are similar to *Pseudotricula* in having two pairs of denticles on the central teeth of the radula, but the shell is trochiform and the outer lip simple and thin in this genus, and it differs also in lacking a seminal receptacle.

None of the subterranean hydrobiids described from New Zealand have a shell like that of *Pseudotricula*, although that of species of *Opacuincola* is somewhat similar (Climo 1974: fig. 12A–F). That genus is characterised by a bifurcate penis and multiple pairs of denticles on the bases of the central teeth. *Hadopyrgus* is the only New Zealand genus with two pairs of basal denticles on the central teeth but has a pupiform shell and an operculum with a white smear on its inner surface. Additional details of the reproductive anatomy of both of these genera are not known.

*Pseudotricula eberhardi* n. sp.

Etymology

Named for Stefan Eberhard, Zoology Department, University of Tasmania, the collector of this and a number of other cave-inhabiting hydrobiids.

Holotype

AMS C.165052. Small stream flowing in Cueva Blanca Cave, near Precipitous Bluff, Tasmania (map 1:25 000 series, *Precipitous*, 4618 662.5 855), 31 Mar. 1986, in turbulent, shallow streamway in dark zone, clinging to smooth rock. Coll.S. Eberhard. 4 paratypes AMS, C.165053, 1 paratype TM, 20151. Same locality, coll. S. Eberhard, 18 Dec. 1988. Very abundant in torrents and waterfalls in Black Curtains stream on smooth bedrock in deep cave zone approximately 150–200 m from entrance (c. 120 paratypes AMS, C. 165054; 10 paratypes TM, 20152). Persephone Pot, Precipitous Bluff (map 1:25 000 series, *Precipitous*, 4618 665 855) in slow-flowing stream with silty substrate in deep zone. Coll. S. Eberhard, 3 Jan. 1990 (2 adults and five juveniles, AMS, C.165055).

The Precipitous Bluff caves (approx. 43°27'51"S, 146°36'51"E) were described and mapped by Eberhard & Hume (1988), who also gave a list of the known fauna, and Hume (1989a, b, 1990).

Description (based on type material only)

Shell (pl.1A). Broadly conical, 2.51–3.01 mm in length; 1.87–2.26 mm in width; white to very pale yellow, periostracum thin, colourless. Protoconch (pl. 1C, D) of 1.5 whorls, microsculpture uniform, minutely punctate (pl.1D). Teleoconch of 2.25–2.5 convex whorls. Teleoconch sculpture of very fine, rather crisp, prosocline growth lines (pl.1C, E); periphery of body whorl evenly rounded. Inner lip moderately thickened, narrow, separated from parietal wall by shallow groove; columellar swelling absent. Outer lip prosocline, with strongly reflected lip, edge thin. Umbilical chink very narrow, 0.01–0.10 mm in width.

Dimensions (table 1)

*Operculum* (pl. 1B, F). Thin, transparent, yellow.

*Radula* (pl. 1G, H). Radular sac extends beyond posterior

end of buccal bulb for about same length as bulb but recurved dorsally into U-shape. Width from outer tip of lateral shaft to median cusp of central tooth in adult 45.5 µm. Central teeth (pl. 1H): dorsal edge with shallow indentations; five lateral cusps on each side, median cusp sharply pointed, longer than adjacent cusps; two (sometimes three) pairs of basal cusps not overlapping dorsal edge of next tooth; lateral edge thickened, at about 45°; mid-basal process wide, U shaped. Lateral teeth: dorsal edge straight to lightly convex; ratio of length of dorsal edge to dorsal shaft about 0.43; basal projection bluntly pointed. Lateral median cusp longer than adjacent lateral cusps, three cusps on inner and four cusps on outer side. Inner marginal teeth with 15–17 cusps, outer marginal teeth with 14–20 cusps (two specimens examined).

*Head-foot* (fig. 1A). Animal unpigmented. Eyes small and black.

*Mantle cavity* (fig. 1B). Ctenidium (ct) narrow, with 9–13 filaments, only in anterior two-thirds of pallial cavity; filament apices on right. Osphradium (os) rather short, oval, slightly curved, wider in middle or at anterior end; anterior end opposite middle of ctenidium, about three filaments from posterior end. Efferent vessel (ev) nearly half length of ctenidium. Hypobranchial gland (hg) well developed, with smooth surface. Rectum (r) s-shaped, occupying much of mantle roof, covered by hypobranchial gland; faecal pellets mostly orientated longitudinally, some obliquely or transversely in coiled part. Renal organ with up to a quarter to (rarely) half of longitudinally orientated renal gland in mantle roof.

*Male genital system* (fig. 2C, 3). Testis occupies about one of two whorls behind stomach and overlaps posterior stomach for about 0.2 whorls. Seminal vesicle narrow, beneath about one-third of first whorl of testis behind stomach, coiled over stomach, with a few coils extending on to digestive gland behind stomach. Prostate gland (fig. 2C), penis (fig. 3) and other details described in generic diagnosis. Penis shows some variation in length of distal end (compare fig. 3A and B).

TABLE 1

|                               | SL*  | SW   | AL   | AW   | BW   | UM   | PD   | TW   |
|-------------------------------|------|------|------|------|------|------|------|------|
| Holotype                      |      |      |      |      |      |      |      |      |
| Mean                          | 2.83 | 2.14 | 1.85 | 1.62 | 2.47 | 0.05 | 0.44 | 2.50 |
| Topotypes (4 males)           |      |      |      |      |      |      |      |      |
| Mean                          | 2.74 | 2.02 | 1.79 | 1.59 | 2.32 | 0.04 | 0.50 | 2.41 |
| SD                            | 0.15 | 0.15 | 0.12 | 0.05 | 0.10 | 0.04 | 0.01 | 0.10 |
| Topotypes (6 females)         |      |      |      |      |      |      |      |      |
| Mean                          | 2.74 | 2.03 | 1.83 | 1.57 | 2.36 | 0.03 | 0.51 | 2.32 |
| SD                            | 0.15 | 0.09 | 0.13 | 0.07 | 0.13 | 0.02 | 0.04 | 0.05 |
| Unsexed paratype (1 specimen) |      |      |      |      |      |      |      |      |
|                               | 2.76 | 2.24 | 1.94 | 1.63 | 2.39 | 0.18 | 0.47 | 2.50 |
| Persephone Pot (2 specimens)  |      |      |      |      |      |      |      |      |
| Mean                          | 3.60 | 2.62 | 2.15 | 1.87 | 2.98 | 0.12 | 0.44 | 2.93 |
| SD                            | 0.16 | 0.07 | 0.02 | 0.07 | 0.16 | 0.02 | 0.01 | 0.03 |

\* AL, aperture length; AW, aperture width; BW, length of body whorl; PD, protoconch diameter; SL, shell length; SW, shell width; TW, number of teleoconch whorls; UM, width of umbilicus.

*Female genital system* (Fig. 2A, B). Ovary occupies 0.5–1.0 of about two whorls behind stomach. Other details given in generic diagnosis.

#### Remarks

This species is unlike any other taxon described from Australasia. Its short-spined shell superficially resembles some species of the *Beddomeia* group from which it can be readily distinguished by the distinctive reflected outer lip of the aperture as well as by the anatomical and radular differences outlined above.

This species has been recorded by Eberhard (in Eberhard & Hume 1988) as "an unidentified species of aquatic snail ... adhering to smooth rock substrate in turbulent sections of the 'Black Curtains' streamway in Cueva Blanca. The shell and body of the snails are white. The snails were abundant and 8 specimens were collected". The specimens of a much larger series collected in December 1988 were fixed in improperly buffered formalin which resulted in serious deterioration of the shells and crystallisation of the neutralising agent in the animal tissues. Those from Persephone Pot are considerably larger than the type series (see dimensions above). However, the shells from the two populations are otherwise very similar and are almost certainly conspecific. The difference in size could be a phenotypic response to the slower-flowing water and/or the muddy sediment in the stream in Persephone Pot.

*Pseudotricula* lives sympatrically with an undescribed hydrobiid in Cueva Blanca Cave and with four other species of hydrobiid in Persephone Pot.

#### DISCUSSION

The existence of a distinctive taxon in a Tasmanian cave opens the possibility of other unique and possibly relict hydrobiid taxa being found in these habitats, as has been the case in some other invertebrate groups (e.g. the spider *Hickmania* [Forster et al. 1987], harvestmen [Hunt 1990], syncarid crustaceans [Lake & Coleman 1977, Knott & Lake 1980], and the coleopteran *Idacarabus* [Moore 1978]). However, a significant proportion of the caves in Tasmania have already been investigated (mainly by S. Eberhard) and, although a number of hydrobiid species have been found which appear to be restricted to (single?) cave systems, most, if not all, of these appear to belong to groups also found in surface waters.

*Pseudotricula eberhardi* appears to be an obligate cave dweller. It lives deep in the cave in which it is found clinging to smooth bedrock in swift-flowing water. The wide aperture seen in *Pseudotricula* is usually associated with this type of habit. The lack of body pigmentation is typical in cave-adapted taxa but the presence of pigmented eyes is not. Consequently, it is conceivable that *Pseudotricula* may not in fact be a long-time cave relict but may have adopted this habitat relatively recently. If this is the case, it is possible that related species may yet be found in surface habitats.

#### ACKNOWLEDGEMENTS

I gratefully acknowledge the assistance of Stefan Eberhard who collected and made available this species and much other cave material from Tasmania. Gerard Clark measured the specimens, and Anne Toluzzi and Geoff Avern prepared and photographed the material for examination with the SEM. Alison Miller assisted with plate preparation, and the final rendering of the drawings was done by Lisa Parkinson. This work was supported in large part by ARC grant A18831777. S. Eberhard and G. Hunt made valuable comments on the manuscript.

#### REFERENCES

- CLIMO, F.M., 1974: Description and affinities of the subterranean molluscan fauna of New Zealand. *NZ J. Zool.* 1(3): 247–284.
- CLIMO, F.M., 1977: Notes on the New Zealand hydrobiid fauna (Mollusca: Gastropoda: Hydrobiidae). *J. R. Soc. NZ* 7(1): 67–77.
- DAVIS, G. M., 1979: The origin and evolution of the gastropod family Pomatiopsidae, with emphasis on the Mekong River Triculinae. *Acad. Nat. Sci. Phila., Mon.* 20: i–vii, 1–120.
- DAVIS, G.M., KITIKOON, V. & TEMCHAROEN, P., 1976: Monograph on "*Lithoglyphopsis*" *aperta*, the snail host of Mekong River schistosomiasis. *Malacologia* 15(2): 241–287.
- DAVIS, G.M., SUUBA RAO, N.V. & HOGLAND, K.E., 1986: In search of *Tricula* (Gastropoda: Prosobranchia): *Tricula* defined, and a new genus described. *Proc. Acad. Nat. Sci. Phila.* 138(2): 426–442.
- EBERHARD, S. & HUME, N., 1988: Report of the Tasmanian Caverneering Club 1986 speleological reconnaissance expedition to Precipitous Bluff. *Speleo Spiel, Newsl. Tasm. Cavern. Club* 237: 1–19.
- FORSTER, R.R., PLATNICK, N.I. & GRAY, M.R., 1987: A review of the spider superfamilies Hypochiloidea and Austrochiloidea (Araneae, Araneomorphae). *Bull. Am. Mus. Nat. Hist.* 185(1): 1–116.
- HUME, N. (Ed.), 1989a: 1988/89 Precipitous Bluff Expedition — part 1. *Speleo Spiel, Newsl. Tasm. Cavern. Club* 252: 1–12.
- HUME, N. (Ed.), 1989b: 1988/89 Precipitous Bluff Expedition — part 2. *Speleo Spiel, Newsl. Tasm. Cavern. Club* 253: 1–12.
- HUME, N., 1990: 1989/1990 Precipitous Bluff Expedition — part 1. *Speleo Spiel, Newsl. Tasm. Cavern. Club* 258: 1–12.
- HUNT, G.S., 1990: *Hickmanoxymma*, a new genus of cavernicolous harvestmen from Tasmania (Opiliones: Triaenonychidae). *Rec. Aust. Mus.* 42: 45–68.
- KNOTT, B. & LAKE, P.S., 1980: *Eucrononaspides oinotheke* gen. et sp.n. (Psammaspidae) from Tasmania, and a new taxonomic scheme for Anaspidae (Crustacea, Syncarida). *Zool. Scrip.* 9: 25–33.
- LAKE, P.S. & COLEMAN, D.J., 1977: On the subterranean syncarids of Tasmania. *Helictite* 15(1): 12–17.
- MOORE, B.P., 1978: A new species of the Tasmanian cave carabid genus *Idacarabus* (Coleoptera). *Aust. Entomol. Mag.* 5(2): 23–25.
- PONDER, W.F., 1966: On a subterranean snail and a tornid from New Zealand. *J. Malacol. Soc. Aust.* 10: 35–40.
- PONDER, W.F. 1991: The eastern seaboard species of *Jardinella* (Mollusca, Gastropoda, Hydrobiidae), Queensland rainforest-inhabiting freshwater snails derived from the west. *Rec. Aust. Mus.* 43: 275–289.

- PONDER, W.F. & CLARK, G.A., 1990: A radiation of hydrobiid snails in threatened artesian springs in western Queensland. *Rec. Aust. Mus.* 42: 301–363.
- PONDER, W.F., CLARK, G.A., MILLER, A.C. & TOLUZZI, A., in press: On a major radiation of freshwater snails in Tasmania and eastern Victoria — a preliminary overview of the *Beddomeia* group (Mollusca: Gastropoda: Hydrobiidae).
- PONDER, W.F., COLGAN, D.G. & CLARK, G.A., 1991. The morphology, taxonomy and genetic structure of *Tatea* estuarine snails from temperate Australia (Mollusca: Gastropoda: Hydrobiidae). *Aust. J. Zool.* 39: 447–497.
- PONDER, W.F., HERSHLER, R. & JENKINS, B., 1989. An endemic radiation of hydrobiid snails from artesian springs in northern South Australia: their taxonomy, physiology, distribution and anatomy. *Malacologia* 31(1): 1–140.

(accepted 9 August 1991)

## THE LACEWINGS (INSECTA, NEUROPTERA) OF TASMANIA

by T.R. New

(with 138 text-figures)

NEW, T.R., 1992 (31:x): The lacewings (Insecta, Neuroptera) of Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 29–45. ISSN 0080–4703. Department of Zoology, La Trobe University, Bundoora, Victoria, Australia 3083.

A synopsis is given, with keys provided for identification, of the 40 species of Neuroptera known from Tasmania and the Bass Strait Islands. Nine families are represented; the Australian mainland families Neurothidae, Berothidae, Psychopsidae, Nemopteridae and Ascalaphidae have not been recorded. A family-level key to larvae is given. Notes on the biology and distribution of all species are provided. Endemism is low, and only two species, *Kempynus longipennis* (Walker) and *Dictyochrysa latifascia* Kimmins, are believed to be restricted to the State; most other species are widespread in southeastern Australia or more widely distributed.

**Key Words:** lacewings, Neuroptera, Tasmania, key, insects, distribution.

### INTRODUCTION

Neuroptera, or Planipennia, are amongst the most primitive groups of endopterygote insects and occur in most temperate and tropical parts of the world. The order includes around 5000 described species of the taxa, commonly known as “lacewings”, “dusty wings”, “sponge-flies”, “owl-flies”, “antlions” and others. They are thus diverse in appearance, and specialists are not yet fully agreed about the relationships between the various families.

Adults are so diverse that unifying features between all families are difficult to find. A closer relationship is demonstrated by the larvae. Larvae have suctorial mouthparts in which the mandible and maxilla of each side are usually elongated and closely associated to form a sucking tube. Larvae of many species are unknown, but at least fragmentary data are available on most families — only for the unusual oriental family Rapismatidae are no larval details known.

Neuroptera are included in the superorder Neuropteroidea, together with the Megaloptera (alderflies, dobsonflies) and Raphidioptera (snake-flies: not in Australia). The latter groups are sometimes included in the Neuroptera but are now most commonly considered to constitute distinct orders; their larvae have chewing mouthparts and, thus, differ clearly from those of Neuroptera *s. str.* The ordinal name “Planipennia” is commonly applied to this restricted complement of the Neuroptera.

Both adults and larvae of the various families are, for the most part, very distinctive. The form of the egg may also be characteristic at this level.

Most recent Neuroptera are terrestrial, and the two families with truly aquatic larvae constitute only minor components of typical freshwater faunas. The terrestrial taxa fall into two major ecological groupings: (1) those in which larvae are almost always found on vegetation, where they feed on a range of small, soft-bodied arthropods, such as aphids, scale insects and psyllids (lerp insects); (2) ground-dwelling forms which may even be subterranean and spend much of their time buried in sand, soft soil or litter. Others are predominantly cortical or subcortical and, as with some ground-dwellers, may emerge from their “retreats” to forage more actively by night. Rarely (Mantispidae) larvae have an obligate “parasitic” relationship with spider egg cases and are found only in association with such specialised habitats. Free-living larvae of several families habitually cover themselves

with debris, including sand, vegetable fragments and lichens, or remains of prey organisms.

Eggs are laid on vegetation or more casually scattered on/in soil, singly or in batches of varying sizes — the particular oviposition pattern usually being very characteristic of given taxa. Eggs of most families are cemented directly to the substrate, but those of Chrysopidae, Mantispidae, Berothidae and Nymphidae are stalked. Hatching occurs by the use of an oviraptor, or by removal of a circular cap via a predetermined “line of weakness” in the chorion. Eggs are generally not ornamented, although those of some Osmylidae have prominent chorionic projections and a well-defined micropyle. There are normally three larval instars, and pupation occurs within a silken cocoon from which the decticious pupa emerges (or partially emerges) before the final moult to adult stage.

As with many other groups of little-studied insects, detailed ecological information on particular species is only rarely available. The most intensively studied Neuroptera are those which have been valued as predators in biological control programmes — especially the green lacewings (Chrysopidae) (Canard *et al.* 1984), the brown lacewings (Hemerobiidae) and, to a much lesser extent, the dusty-wings (Coniopterygidae).

Riek (1970) noted only seven species of Neuroptera from Tasmania, out of a total of 396 Australian species. Since then, considerable taxonomic work has been undertaken on the Australian fauna, and the revised edition of *The Insects of Australia* notes that 623 Australian species have now been recognised (New 1991). Endemicity is very high, with well over 90% of Australian lacewings not yet known from elsewhere. The minimum number of Tasmanian species is now 40, and additions are likely in, especially, Coniopterygidae and Sisyridae, in which undescribed and poorly documented species occur. Neither has been the subject of a major revision in recent years, although Meinander's (1972) monograph of Coniopterygidae included all Australian species then known. With the exception of these families, however, a reasonably accurate or informed account of the Tasmanian fauna is now feasible. No faunal account should ever be considered to be fully definitive, but records such as the present can serve to provide a reference point protem and stimulate interest towards further, more detailed documentation, and indicate the areas needing more intensive concentration. Nine of the 14 lacewing families in

Australia have now been confirmed from Tasmania, although there are very few records of some of these.

In general, the Tasmanian Neuroptera represent an attenuation of the mainland Australian fauna, and a number of the species present are limited to the eastern Bassian province. Others are widespread on the mainland. Only two species, an archaic chrysopid and an osmylid, are at present believed to be wholly endemic to Tasmania. Both belong to endemic Bassian genera and have close relatives in southeastern Australia. Relatively few species seem to be common in the state, and a few early records are anomalous and have now been confirmed by more recent collecting. Several families occurring in Victoria and other parts of south or eastern Australia have not yet been found in Tasmania but may be genuinely absent. Nemopteridae, confined to semi-arid and arid regions, are not likely to occur there. The same is true of Berothidae, and it is unlikely that such large conspicuous insects as Ascalaphidae and Psychopsidae would have escaped detection in Tasmania, although particular species occur in Victoria and South Australia. In contrast, Neurorthidae may well have been overlooked. Their distinctive larvae are not uncommon in cold streams in Victoria, but the adults are only rarely collected. They should be sought in similar habitats to Sisyridae and some Osmylidae. Several of these families are included in the following keys and brief notes are provided to alert the reader's attention to their possible presence. Very few Neuroptera have been recorded from Bass Strait islands. Comments on the broader distribution of the various Tasmanian taxa are included below, and names of all taxa not actually recorded from the state are indicated by an asterisk. Detailed distribution records for most of the species in Tasmania are premature, as the small amount of specialist

collecting inevitably renders existing data very incomplete, but general comments are given where possible.

## IDENTIFICATION

The following keys incorporate a range of structural characters. They have been designed on a rather broader basis than for the Tasmanian fauna alone, as those to family level for adults and late instar larvae both include several families which are not known from Tasmania but occur elsewhere in southeastern Australia and could possibly occur in the state. At this level, the groups are recognisable on gross features, there is no need for dissection, and a good hand lens or low-power binocular microscope will be adequate for examination. Use of keys to members of each family, in which selected non-Tasmanian taxa are also included, sometimes necessitates close examination of particular adult features, especially those of wing venation and genitalic structures. Larvae cannot be identified confidently beyond family level, as most have now been clearly associated with adults of particular species by rearing.

Wing venation can normally be examined adequately on preserved specimens. The patterns of the various families are very distinct, and it is sometimes difficult to reconcile superficially the venation of one family with that of even closely-related others. Coniopterygidae have relatively simplified venation, but it is more complex in other families. Nomenclature used follows that in recent taxonomic accounts. Many body features, likewise, are discernible without dissection. In some instances, it may be necessary to examine genitalic structure for specific identification.

Taxa not recorded from Tasmania are indicated by an asterisk (\*).

## CHECKLIST OF TASMANIAN NEUROPTERA

Full synonymies of all taxa are listed in the works cited in the "References".

### Family Coniopterygidae

- Cryptosceneae australiensis* (Enderlein)
- Neosemidalis* (*Leucosemidalis*) *farinosa* (Enderlein)
- N.* (*Neosemidalis*) *nervalis* Meinander
- Coniopteryx* (*Xeroconiopteryx*) *maculithorax* Enderlein
- Heteroconis nigripennis* Meinander

### Family Ithonidae

- Ithone pallida* (Tillyard)

### Family Osmylidae

- Kempynus longipennis* (Walker)
- Stenosmylus tenuis* (Walker)
- Oedosmylus tasmaniensis* Krüger
- O. latipennis* Kimmins

### Family Mantispidae

- Calomantispa venusta* Lambkin
- Campion rubellus* Navas
- C. tenuistriga* (Gerstaecker)
- C. australasiae* (Guerin)
- C. cruciferus* (Navas)
- C. impressus* (Navas)
- C. callosus* Lambkin

### Family Sisyridae

- Sisyra* spp.

### Family Hemerobiidae

- Psychobiella sordida* (Banks)
- Psectra nakaharai* New
- Notherobius nothofagi* New
- Micromus tasmaniae* (Walker)
- Drepanacra binocula* (Newman)
- Megalomina berothoides* (McLachlan)
- Zachobiella submarginata* Esben-Petersen

### Family Chrysopidae

- Dictyochrysa latifascia* Kimmins
- D. peterseni* Kimmins
- Nothancyla verreauxi* Navas
- ?*Ankylopteryx immaculata* Brauer
- Italoichrysa insignis* (Walker)
- Apertochrysa edwardsi* (Banks)
- Mallada signata* (Schneider)
- M. tripunctata* (McLachlan)

### Family Nymphidae

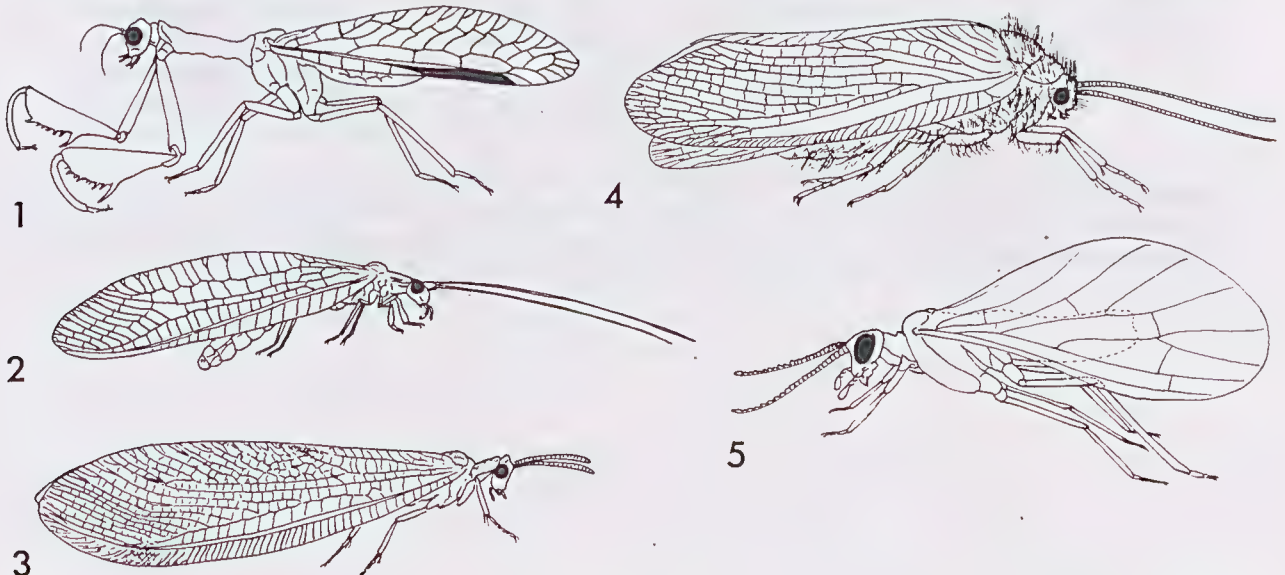
- Nymphes myrmeleonides* Leach

### Family Myrmeleontidae

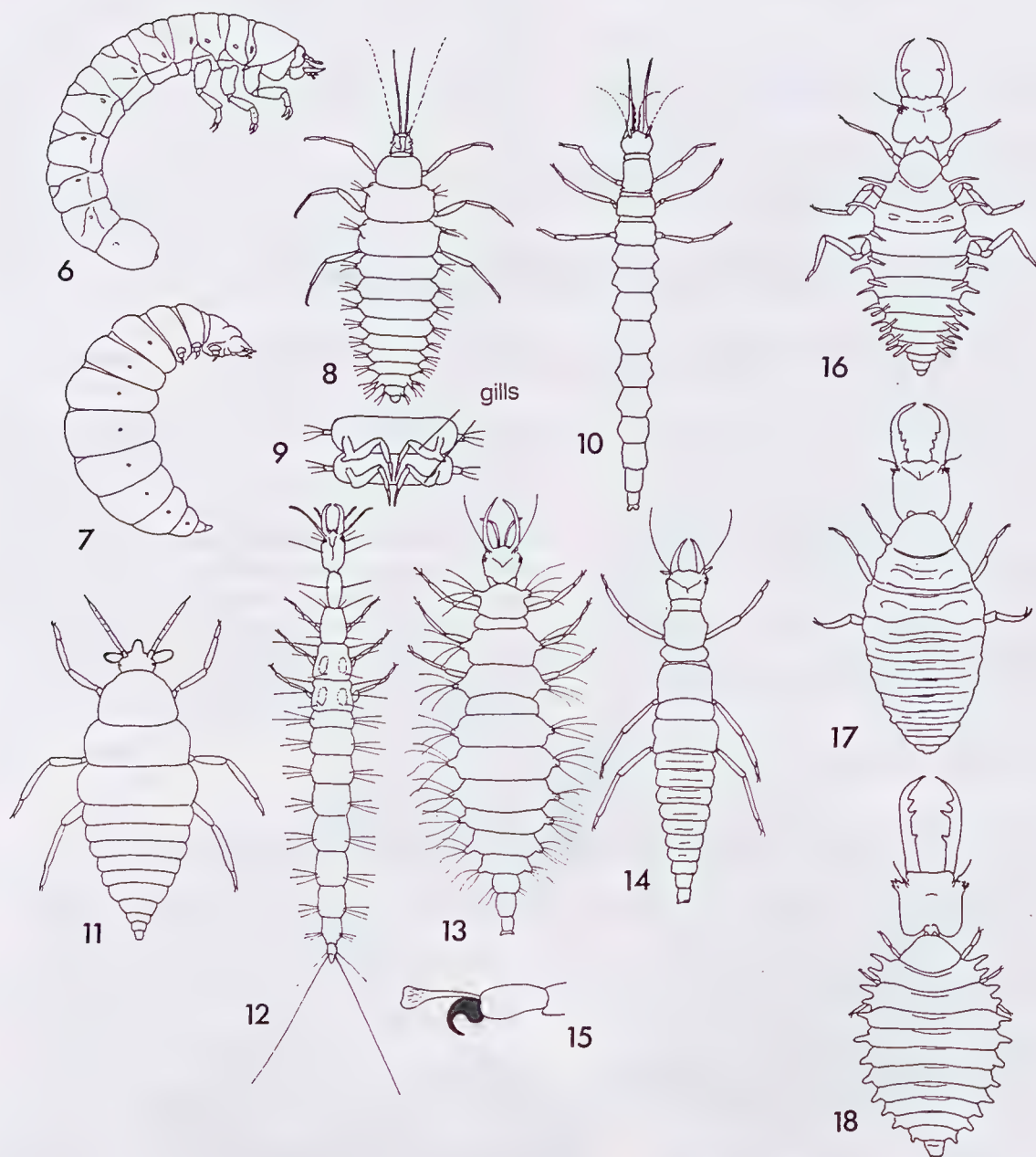
- Myrmeleon acer* Walker
- Glenoleon falsus* (Walker)
- Mossega indecisa* Banks
- Escura australis* (Esben-Petersen)
- Bandidus vafer* (Walker)
- Heoclisia fundata* (Walker)

# KEY TO FAMILIES: ADULTS

- 1 Very small insects, fore wing length to about 4 mm, usually less; usually white or grey, due to wings and much of body being covered with waxy secretion; costal area with, at most, one or two basal crossveins (fig. 5) ..... Coniopterygidae
- Larger, not waxy; costal area with more numerous crossveins ..... 2
- 2(1) Fore legs raptorial, femur strongly thickened and spined; prothorax greatly elongated (fig. 1) ..... Mantispidae
- Fore legs not raptorial; prothorax relatively short ..... 3
- 3(2) Antennae strongly clubbed, at least half of fore wing length ..... \* Ascalaphidae
- Antennae usually filiform or moniliform, sometimes with apex gradually broadened: if incipiently clubbed, much shorter than half fore wing length ..... 4
- 4(3) Short, stout body; hind wing very broad at base (dark greyish brown, mothlike) (fig. 4). ..... Ithonidae
- Not as above: if body stout (rare), hind wing no broader than fore wing at base. .... 5
- 5(4) Antennae distinctly thickened distally, or incipiently clubbed; wings rather narrow (fig. 3). ..... Myrmeleontidae
- Antennae not as above : if thickened, uniform along length ..... 6
- 6(5) Fore wing vein Sc fused distally with R<sub>1</sub> and Rs to form "vena triplica"; these three veins running closely parallel ..... \* Psychopsidae
- Not as above: "vena triplica" not formed ..... 7
- 7(6) Ocelli present, at least represented by raised tubercles on vertex (usually moderately large, brown-winged species) ..... Osmylidae
- Ocelli absent ..... 8
- 8(7) Veins Sc and R<sub>1</sub> fused apically for considerable distance; fore wing vein CuA usually forming large convex enclosed triangular area ..... Nymphidae
- Veins Sc and R<sub>1</sub> linked by crossvein towards apex; fore wing vein CuA not as above ..... 9
- 9(8) Fore wing with at least two apparent Rs veins arising from vein R ..... Hemerobiidae
- Fore wing with only single Rs, arising from vein R near base ..... 10
- 10(9) Hind wing vein CuA not running close to hind margin for at least half wing length; venation of both wings somewhat reticulate (medium to large species, fore wing usually at least 10 mm, brown or green) (fig. 2) ..... Chrysopidae
- Hind wing vein CuA running close to hind margin usually for at least half wing length (small, brown species, fore wing length to about 7 mm) ..... 11
- 11(10) Fore wing costal crossveins simple (fig. 84) ..... Sisyridae
- Some fore wing costal crossveins forked (fig. 38 ) ..... \* Neurorthidae



FIGS 1-5 — Representative lacewings, lateral aspect: 1, Mantispidae; 2, Chrysopidae; 3, Myrmeleontidae; 4, Ithonidae; 5, Coniopterygidae.

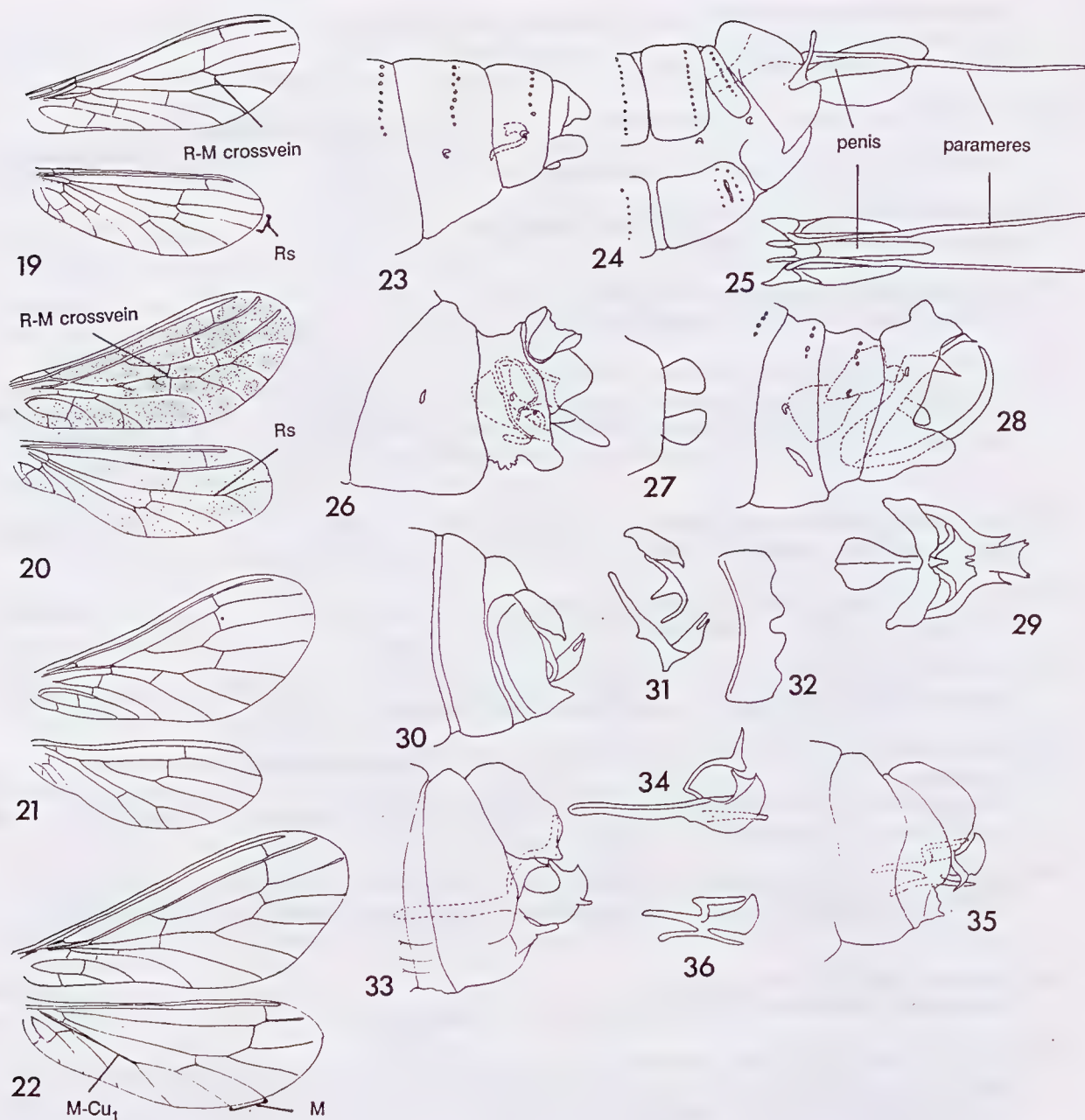


FIGS 6-18 — Lacewing larvae, to indicate general appearance — note varying forms of body and mouthparts; 6, *Ithonidae*; 7, *Mantispidae*; 8, *Sisyridae*; 9, same, ventral, two abdominal segments to show gills; 10, *Osmylidae*; 11, *Coniopterygidae*; 12, *Neurorthidae*; 13, *Chrysopidae*; 14, *Hemerobiidae*; 15, empodium of *Chrysopidae*; 16, *Nymphidae*, Nymphes; 17, *Myrmeleontidae*, Myrmeleon; 18, *Ascalaphidae*. (6, 7, lateral; 8, 10-14, 16-18 dorsal aspect.)

## KEY TO FAMILIES: LATE INSTAR LARVAE

- 1 Abdomen with seven pairs of ventral gills; labial palpi absent, mouthparts very long and slender (aquatic) (figs 8, 9) ..... *Sisyridae*  
 – No ventral abdominal gills; labial palpi present, mouthparts not as above (usually terrestrial) ..... 2
- 2(1) Labial palpi and antennae both 2-segmented; very small, body length usually 2–3 mm (fig. 11) ..... *Coniopterygidae*  
 – Labial palpi and antennae both with more than two segments; usually larger ..... 3
- 3(2) Mandibles with large preapical tooth/teeth on inner margin ..... 4  
 – Mandibles without preapical tooth/teeth ..... 6
- 4(3) Mandibles with one preapical tooth (fig. 16) ..... *Nymphidae*  
 – Mandibles with more than one (usually three) preapical teeth ..... 5
- 5(4) Lateral body processes weakly developed, often virtually absent — at least along abdomen; hind tarsal claws flexed forwards and enlarged; hind margin of head not strongly lobed (fig. 17) ..... *Myrmeleontidae*  
 – Lateral body processes well-developed, usually two each on mesothorax and metathorax and one on each of (at least) first seven abdominal segments; hind tarsal claws normal; hind margin of head strongly bilobed (fig. 18) ..  
 ..... \**Ascalaphidae*
- 6(3) Body scarabaeiform; tibiae and tarsi fused; eyes absent (fig. 6) ..... *Ithonidae*  
 – Body generally now scarabaeiform; tibiae and tarsi separate; eyes present ..... 7
- 7(6) Tarsi with one claw; mandibles very short ("parasitic" in spider egg sacs) (fig. 7) ..... *Mantispidae*  
 – Tarsi with two claws; mandibles long (freeliving) ..... 8
- 8(7) Mandibles and maxillae inwardly curved from base ..... 9  
 – Mandibles and maxillae straight or, rarely, inwardly curved at apex ..... 11
- 9(8) Frons tapered anteriorly; dorsal surface of head and thorax with dense, short papillae; no longer setae (subcortical) ..... \**Psychopsidae*  
 – Frons not as above; usually with distinct setae on head, thorax or abdomen, or bare (lacking setae and papillae) (usually exposed on vegetation) ..... 10
- 10(9) Empodium trumpet-shaped (fig. 15); thorax and abdomen often with long setae (fig. 13) ..... *Chrysopidae*  
 – Empodium now trumpet-shaped; thorax and abdomen with short setae, sometimes almost bare (fig. 14) .....  
 ..... *Hemerobiidae*
- 11(8) Mandibles and maxillae straight (fig. 10) ..... *Osmylidae*  
 – Mandibles and maxillae inwardly curved at apex (fig. 12) (aquatic) ..... *Neurorthidae*

N.B. For the most part, the above key will work also for earlier instars. Exceptions are: (A) first instar *Sisyridae* have poorly-developed gills, but the mouthparts are distinctive; (B) first instar *Hemerobiidae* have the empodium trumpet-shaped and are virtually identical to *Chrysopidae*; however, *Hemerobiidae* lay unstalked eggs and those of *Chrysopidae* in Australia are invariably stalked; (C) first instar *Mantispidae* differ substantially from later stages in being active triungulinoid larvae, and freeliving.



FIGS 19–36 — *Coniopterygidae*: fore and hind wings: 19, *Neosemidalis* sp.; 20, *Heteroconis nigripennis*; 21, *Coniopteryx* sp.; 22, *Cryptosceneae australiensis*: genitalic structures: 23–25, *Cryptosceneae australiensis* (23, female, apex of abdomen, lateral; 24, male, same; 25, male, extruded genitalia, ventral); 26–29, *Heteroconis nigripennis* (26, female, apex of abdomen, lateral; 27, gonapophyses, ventral; 28, male, apex of abdomen, lateral; 29, male, internal genitalic complex, dorsal); 30–32, *Coniopteryx maculithorax*, male (30, apex of abdomen, lateral; 31, gonarcus and stylus (upper diagram) and paramere (lower diagram), lateral; 32, hypandrium, ventral); 33, 34, *Neosemidalis farinosa*, male (33, apex of abdomen, lateral; 34, internal genitalia, lateral); 35, 36, *N. nervalis*, male (35, apex of abdomen, lateral; 36, internal genitalia, lateral).

## SYNOPSIS OF TAXA

Illustrations provided to aid identifications are simplified to outline drawings, except for some heavily patterned wings; setae are generally omitted to aid clarity of interpretation. More detailed descriptions are given in the revisionary papers cited for each family.

## Coniopterygidae

An isolated family with no close relatives. Cosmopolitan, with about 50 known Australian species. Five have been recorded from Tasmania, and others are likely to occur. The world fauna was monographed by Meinander (1972, 1990), and the most recent synopsis of the Australian species is his 1972 account.

Coniopterygidae, dusty wings, are by far the smallest lacewings. Few are more than 3 mm in wing length, and they generally appear white or pale grey, although some have distinctive black markings on the forewing, which become more visible after wax is removed by alcohol storage. They can easily be mistaken for white flies (Homoptera) and are predominantly arboreal. Adults are often beaten from trees and shrubs, and only more rarely swept from low vegetation.

Two major subfamilies occur, both represented in Tasmania.

- 1 Fore wing with 1 R-M crossvein, near centre of wing (fig. 21); hind wing vein Rs not arising from R near base of wing (fig. 21) ..... Coniopteryginae
- Fore wing with 2 R-M crossveins (fig. 20); hind wing vein Rs arising near wing base (fig. 20) ..... Aleuropteryginae

## Coniopteryginae

- 1 Hind wing vein M simple, not forked .... *Coniopteryx*
- Hind wing vein M forked ..... (*Neosemidalis*).2
- 2(1) Wings grey, sparsely covered with wax grains ..... s.g. *Neosemidalis*
- Wings hyaline, with thick coating of wax ..... s.g. *Leucosemidalis*.

*Coniopteryx* Curtis

A worldwide genus, with subgenera and species separable mainly on details of male genitalia. The single recorded Tasmanian species, *C. (Xeroconiopteryx) maculithorax* Enderlein (figs 30–32), belongs to a small group of Australian species characterised by having forked styli (fig. 31). It is widely distributed in Tasmania and eastern mainland Australia (Q, NSW, V). Other species in this group are *C. occidentalis* Meinander (WA, Q, NSW), *C. orientalis* Meinander (Q, NSW) and *C. tillyardi* Meinander (Q, NSW). All four species have large, dark-brown “shoulder spots”, and it is possible that others could occur in both Tasmania and Victoria. They are separable, in part, as follows: females are virtually impossible to differentiate simply, and the most reliable characters are those of the male genitalia.

- 1 Male flagellar segments with scale-like hairs ..... 2
- Male flagellar segments without scale-like hairs ..... 3
- 2(1) Terminal process in ventral view large; median apical incision of hypandrium V-shaped ..... \* *C. tillyardi*
- Terminal process in ventral view small; median apical incision of hypandrium U-shaped ..... \* *C. orientalis*
- 3(1) Hypandrium with median apical incision large and V-shaped ..... *C. occidentalis*
- Hypandrium with median apical incision U-shaped (fig. 32) ..... *C. maculithorax*

*Neosemidalis* Enderlein

A genus limited to the Australian region, with approximately 15 Australian species and few elsewhere. The two Tasmanian species (with few records from forested areas in the State) represent different subgenera, and specific differences in both these are largely those of male genitalia and male antennae.

*N. (N.) nervalis* Meinander (figs 35, 36) is one of a group of species with the male antennal scape distinctly broader than long and the hind wing M-Cu<sub>1</sub> crossvein striking the posterior branch of vein M (rather than the stem of M). The latter feature allies it with \**N. (N.) anguliceps* Meinander (NSW), which has long projecting genae; genae are normal in *N. nervalis*, which is widely distributed in Australia (WA, SA, Q, NSW, V).

*N. (L.) farinosa* (Enderlein) (figs 33, 34) is allied with \**N. (L.) acuta* Meinander (Q, NSW) by having parameres without a ventral tooth, but the hypandrium of *N. farinosa* is obscure rather than being distinct and acute.

## Aleuropteryginae

Two genera are recorded from Tasmania.

- 1 Hind wing radial crossvein meeting Rs on R<sub>2+3</sub>; fore wing R<sub>4+5</sub> superficially resembling anterior branch of M; (hind wing veins M and Cu<sub>1</sub> very close for more than half length of Cu<sub>1</sub>, so no clear space between them) (fig. 22) ..... (Fontenelleini) .. *Cryptosceneae*
- Hind wing radial crossvein meeting Rs on stem or fork; vein M forked in both wings, anterior branch of fore wing vein M coalescing with, or connected by crossvein to, R<sub>4+5</sub> (fig. 20) ..... (Aleuropterygini) .... *Heteroconis*

*Cryptosceneae* Enderlein

A rather small genus occurring in Australia, New Zealand and New Guinea. *C. australiensis* (Enderlein) (figs 23–25) is the most common species and, as well as Tasmania (widely distributed), is recorded from Q, NSW, V and New Zealand (where it has been introduced). The male is very distinctive in having the parameres about twice as long as the penis (fig. 25). In all other described species, the parameres and penis are of similar length.

*Heteroconis* Enderlein

The predominant genus of Aleuropteryginae in Australia, New Guinea and the Oriental Region. The sole species recorded from Tasmania (where it seems to be rare), *H. nigripennis* Meinander (figs 26, 29), is known also from WA, Q, NSW, V. The species are best separated on male characters and details of the position of fore wing crossveins in relation to the thickened spots on vein M.

## Ithonidae

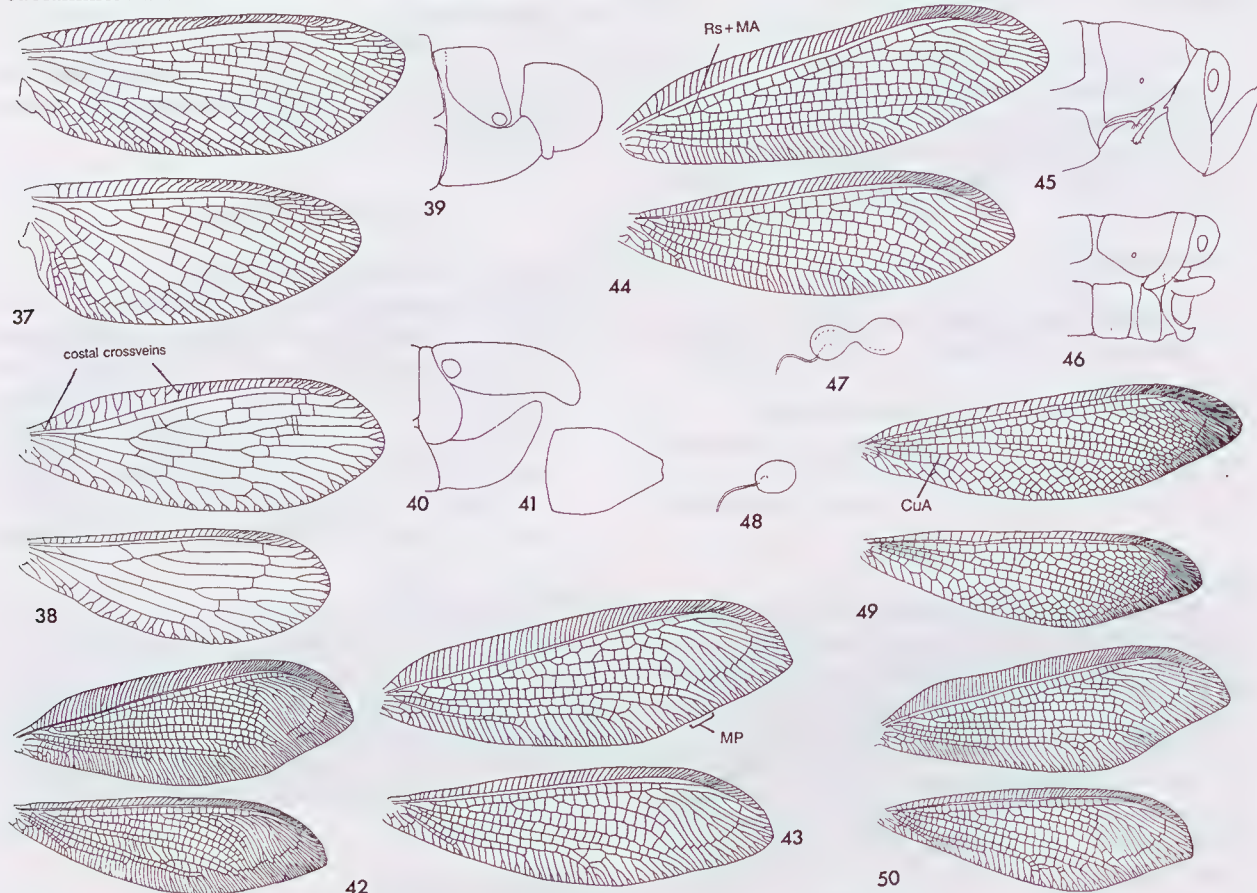
A very primitive and isolated family of Neuroptera, known from 14 species (in three genera) from Australia and a single genus and species from western North America. "Moth lacewings" have stout furry bodies and broad wings with dense venation; their common name comes from a superficial resemblance to small hepialid moths. They are associated particularly with sandy areas, and adults sometimes occur in very large numbers, due to mass emergences. Larvae are unlike those of any other lacewings, being scarabaeiform and subterranean. It was formerly presumed that they were predators on larvae of scarab beetles, but they are now believed to feed on exudates from plant material — a highly unusual habit for larval Neuroptera.

Only one species, *Ithone pallida* (Tillyard) (figs 37, 39–41), is known from Tasmania (few records from the northeast) and is also widespread in NSW and V (Riek 1974). The ten species of *Ithone* Newman are concentrated around coastal southern Australia and have largely discrete geographical ranges. *I. pallida* is most similar to *\*I. neopallid* Riek (SA) but differs in having the mandibles straight rather than apically curved and in the gradually tapered apical sternite of the male.

About 40 species of this family are known from Australia, representing five subfamilies. Representatives of two subfamilies have been recorded from Tasmania and a third

(containing a single species widespread in southeastern mainland Australia) is noted, although it seems unlikely that it would have escaped notice in the state until now. All three are southern groups and in Australia are restricted to the Bassian Province. Kempyninae and Stenosmylinae occur also in temperate South America, and the former in New Zealand. Larvae of Kempyninae are thought to be semiaquatic, as the adults (which are amongst the largest Osmylidae) often occur commonly near streams or rivers, and larvae have been found amongst low waterside vegetation. Stenosmylinae are generally more clearly terrestrial, and larvae have been found on and under bark in open forest environments. All seem to have one generation a year, with adults flying in summer.

- 1 Many crossveins between veins  $R_1$  and  $R_s$  (steely blue and ivory/yellow wings) .....  
..... \*Porisminae (\**Porismus strigatus* Burmeister)
- A single, basal, crossvein between veins  $R_1$  and  $R_s$  (variously marked with brown and grey). ..... 2
- 2(1) Fore wing vein MP forked near base of wing, usually between separation of MA from  $R_s$  and first branch of  $R_s$  proper from stem, sometimes opposite MA/ $R_s$  separation (fig. 43) ..... Kempyninae (*Kempynus*)
- Fore wing vein MP forked more distally, usually beyond half wing length (figs 44, 50) ..... Stenosmylinae



FIGS 37–43 — Fore and hind wing venation: 37, *Ithone* sp. (*Ithonidae*); 38, *Austroneurorthus* sp. (*Neurorthidae*); *Ithone pallida*, genitalic features; 39, female, apex of abdomen, lateral; 40, male, same; 41, male, last sternite, ventral. Fore and hind wings of 42, *Oedosmylus tasmaniensis*; 43, *Kempynus longipennis* (*Osmylidae*).

FIGS 44–50 — 44–46: *Stenosmylus tenuis*: 44, fore and hind wings; 45, female, apex of abdomen, lateral; 46, male, same; 47, 48 Spermatheca of 47, Kempyninae; 48, Stenosmylinae. Fore and hind wings: 49, *Nymphes myrmeleonides* (*Nymphidae*); 50, *Oedosmylus latipennis* (*Osmylidae*).

## Kempyninae

Three genera and 13 species of this group occur in Australia. *Kempynus* Navas is the largest genus and occurs also in New Zealand. The only Tasmanian kempynine, *K. longipennis* (Walker) (figs 51, 52), is apparently endemic to the state, where it is widely distributed, but the provenance of the type specimen (labelled only "Australia") is unknown. It seems to be most closely related to the Victorian \**K. millgrovensis* New, and differs by the less sinuous fore wing margin and by the female gonocoxite VII not being produced dorsally near its apex. The spermathecae of *Kempynus* are dumbbell-shaped, in contrast to the spherical spermathecae of the other Tasmanian Osmylidae.

## Stenosmylinae

Two genera are represented in Tasmania, of five known in Australia. Two others occur in South America. A third mainland genus, not uncommon in Victoria, is noted in the following key.

- 1 Fore wing vein MP *apparently* forking distally only slightly before wing margin ..... 2
- Fore wing vein MP conspicuously forking around half (at most, two-thirds) length of wing (fig. 50) ..... *Oedosmylus*
- 2(1) Fore wing vein 2A terminating opposite, or slightly beyond, origin of Rs+MA (fig. 44) ..... *Stenosmylus*
- Fore wing vein 2A terminating opposite, or slightly basal to, separation of MA from Rs ..... \**Stenolysmus* Kimmins

*Stenosmylus* McLachlan

Represented by *S. tenuis* (Walker) (figs 44–46), a narrow-winged, brown-mottled species which can be very common; known also from WA, SA, NSW and V. In Victoria it occurs sympatrically with another common species, \**S. stenopterus* McLachlan, which differs in having a pronounced longitudinal dark-brown streak along the fore wing.

*Oedosmylus* Krüger

*Oedosmylus* contains eight species (New 1989b), of which two very closely related ones are found in Tasmania. Indeed, there is still some doubt as to whether they are really distinct, although some small differences seem to be relatively consistent. *O. montanus* Kimmins (Q, NSW) is also in this species complex.

- 1 Wings ovoid ..... *O. tasmaniensis*
- Wings falcate ..... *O. latipennis*

*O. tasmaniensis* Krüger (figs 53, 54) (also NSW, V) and *O. latipennis* Kimmins (figs 55, 56) (NSW, V) also overlap in range in Tasmania, although a number of localities have so far yielded only one of these two species. The accompanying figures indicate small differences in the genitalia of both sexes, though the wing shape is by far the most reliable character for most individuals seen; which can be allocated unambiguously to one or other name on this feature alone.

## Sisyridae

The "sponge-flies", small, narrow-winged, brown or grey lacewings found close to fresh water. Larvae are specialised obligate "parasites" of freshwater sponges and, probably, bryozoans, and sisyrids are thus limited to areas in which these organisms occur.

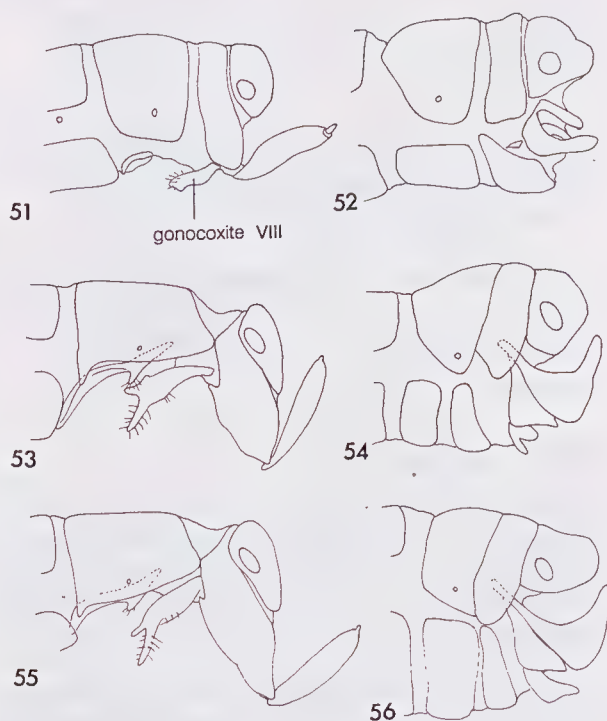
The family is in need of revision and little can be done to identify the Tasmanian representatives at this stage. Sisyrids appear to be reasonably common in Tasmania, as in other parts of southeastern Australia, but there are no published records (with species names) from the state. Several species occur also in Victoria and perhaps elsewhere in the southeast. *Sisyra* is the predominant genus.

Sponge-flies can be confused only with Hemerobiidae and Neurothidae, both of which differ in venational features (fig. 84). Genitalia differ markedly between these three families.

## \*Neurothidae

No records from Tasmania; but the distinctive larva (fig. 12) and the wing venation (fig. 38) of a mainland species of \**Austroneurothus* Nakahara are figured here. Larvae occur in Victoria, particularly in alpine streams. The adult most resembles those of Sisyridae but is rather larger, and at least some fore wing costal crossveins are forked; they are invariably simple in Sisyridae.

Neurothidae were formerly considered to be a subfamily of Sisyridae, but have been recognised as a distinct family for about 20 years. There are probably two Australian species.



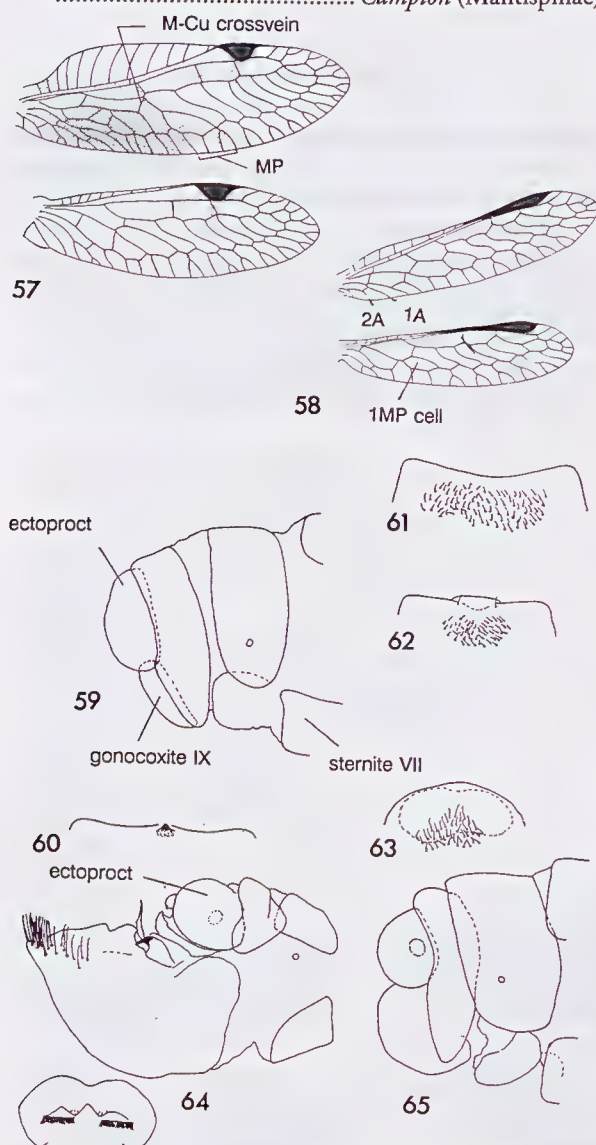
FIGS 51–56 — Osmylidae, genitalic features (51, 53, 55, female; 52, 54, 56, male), apex of abdomen, lateral: 51, 52, *Kempynus longipennis*; 53, 54, *Oedosmylus tasmaniensis*; 55, 56, *O. latipennis*.

## Mantispidae

Mantispids resemble small praying mantids in having enlarged raptorial fore legs, hence their common name of "mantis-flies". They are completely distinctive in the Australian Neuroptera and 46 Australian species are known.

The seven Tasmanian species represent two genera, in different subfamilies, following the arrangement of Lambkin (1986a, b).

- 1 Anterolateral margins of mesoscutum rounded; fore tarsus with segment 1 much shorter than segments 2–5 together; two claws, each deeply divided ..... *Calomantispa* (Calomantispinae)
- Anterolateral margins of mesoscutum acutely extended; fore tarsus with segment 1 at least as long as segments 2–5 together; one claw; mid and hind claws simple ..... *Campion* (Mantispinae)



FIGS 57–65 — Mantispidae: fore and hind wings of 57, *Calomantispa venusta*; 58, *Campion callosus*: genitalic structures: 59, *Campion* sp., female, apex of abdomen, lateral; 60–63, *Campion* spp., female, sternite VII, ventral: 60, *C. callosus*; 61, *C. australasiae*; 62, *C. impressus*; 63, *C. tenuistriga*; 64, 65, *Calomantispa venusta*: 64, male, apex of abdomen, lateral, with posterior view of ectoproct ornamentation; 65, female, apex of abdomen, lateral.

The most diverse genus of Mantispidae in Australia, the endemic \**Theristria* Gerstaecker, has not been recorded from Tasmania, although several species occur in the southeastern mainland states. It is placed in a third subfamily, \*Drepanicinae, which has a rounded mesoscutal margin and simple fore tarsal claws.

*Calomantispa* Banks

The only Australian genus of Calomantispinae, a group otherwise known only from North America, is limited to eastern Australia and is distinguishable from all other Australian mantispid genera by the bifid fore tarsal claws. The three species are all brightly coloured, with the fore wings marked with bright orange. The sole Tasmanian species, *C. venusta* Lambkin (figs 57, 64, 65) (also NSW, V), has two small setose anterodorsal prominences on the vertex, and fore wing vein MP forks beyond the second M-Cu crossvein. In both the other species (\**C. spectabilis* Banks, Q; \**C. picta* Stitz, NSW), the vertex lacks setose humps and fore wing vein MP forks basal to 2m-cu.

*Campion* Navas

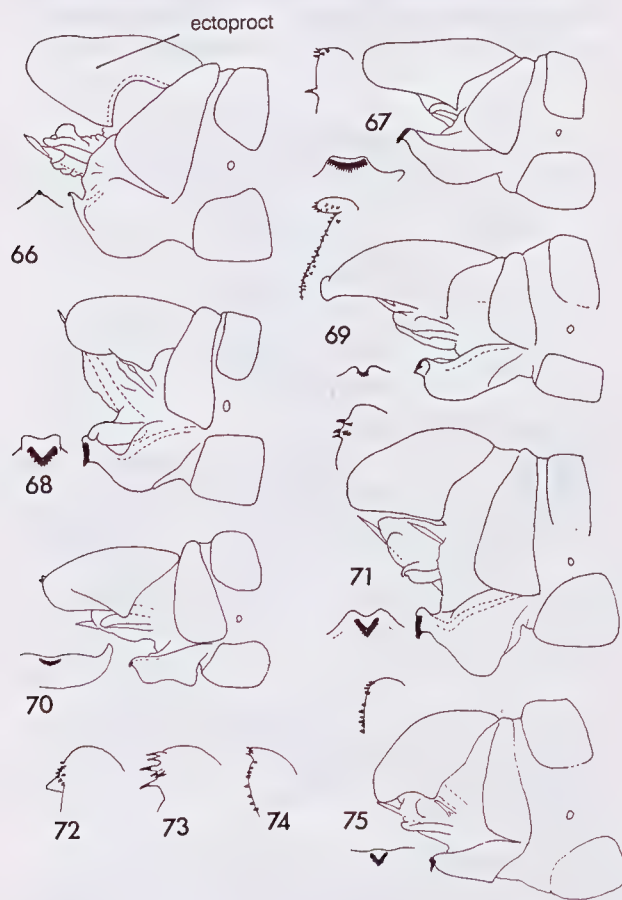
This Australian endemic genus contains seven species, six of which are recorded from Tasmania. The other, \**C. spiniferus* Lambkin, is known from WA, V, NSW, SA (including Kangaroo Island) and could possibly be found in Tasmania. It is included, therefore, in the following key (from Lambkin 1986b, where many additional details are given). The species are rather similar in gross appearance and genitalic examination is sometimes necessary for unambiguous separation.

- 1 Fore wing jugal lobe large; hind wing with four veins leaving 1 MP cell ..... 2
- Fore wing jugal lobe small; hind wing with three veins leaving 1 MP cell ..... 5
- 2(1) Fore wing vein CuA 4-branched (rarely 3- or 5-branched); veins 1A and 2A each with 2 branches ..... *C. rubellus*
- Fore wing vein CuA 2-branched; veins 1A and 2A both simple ..... 3
- 3(2) Vertex with well-developed median ridge with fine transverse ridges on each side; pronotum 2.6–3.5 times as long as wide at maculae ..... *C. australasiae*
- Vertex smooth, with weakly defined rounded median ridge; pronotum 3.6–5.4 times as long as wide at maculae ..... 4
- 4(3) Female sternite VII with broadly spaced fine posterior setae; male ectoproct with apical half of medial margin with 6–10 randomly placed short thick sessile spines; apex curved medially, acute ..... *C. tenuistriga*
- Female sternite VII with dense patch of thick posterior setae; male ectoproct with apical region of medial margin extended posteriorly and with three spines set on distinct pedestal; apex broad, truncate ..... *C. cruciferus*
- 5(1) Female gonocoxite IX with setae concentrated along medial margin, posterior region of sternite VII simple, without strongly sclerotised area; male, medial margin of ectoproct with four spines, proximal two or three broadly spaced ..... *C. impressus*
- Female gonocoxite IX with setae evenly distributed,

posterior region of sternite VII with strongly sclerotised area; male, medial margin of ectoproct with patch of six closely approximated apical spines ..... 6

- 6(5) Female sternite VII with strongly sclerotised area on posterior margin; male with spines along medial margin of ectoproct very slightly pedestalled ..... *C. callosus*  
 – Female sternite VII with posterior and posterolateral regions strongly sclerotised, rugose; male with spines along medial region of ectoproct at most only slightly pedestalled ..... \**C. spiniferus*

*C. rubellus* Navas (fig. 69) is very widely distributed around the southern half of Australia and is known also from NT. In general, its distribution coincides strongly with that of *C. australasiae* (Guerin) (figs 61, 66, 72), although the latter is known from Flinders Is. and the Furneaux group, as well as "Tasmania proper". *C. tenuistriga* (Gerstaecker) (fig. 75), apparently the most common species of Campion, occurs throughout Australia but has only recently been recorded from Tasmania (Lambkin 1987). *C. cruciferus* (Navas) (figs 70, 74) (NSW, V) is a rarer species, apparently restricted to the southeast of Australia. *C. callosus* Lambkin (figs 58, 60, 68, 73) is predominantly eastern, with a few specimens known from WA. *C. impressus* (Navas) (figs 62, 67) is widely distributed in eastern Australia.



FIGS 66–75 — *Campion* spp., males, apex of abdomen, lateral, with posterior view of last sternite ornamentation and dorsal view of inner margin of ectoproct: 66, 72, *C. australasiae*; 67, *C. impressus*; 68, 73, *C. callosus*; 69, *C. rubellus*; 70, 74, *C. cruciferus*; 71, *C. spiniferus*; 75, *C. tenuistriga*.

## Hemerobiidae

Small, generally brown lace wings, always with at least two Rs veins arising directly from vein R, often with three–five such veins; wings sometimes falcate. Larvae are active campodeiform predators and never carry debris (cf. Chrysopidae). They occur on vegetation, predominantly trees and shrubs. There are 35 Australian species, nearly all endemic. The seven Tasmanian species all represent different genera, two being here formally recorded from the state for the first time. The most diverse Australian genus, \**Carobius* Banks, has now been found in Tasmania but is included in the following key. Subfamily divisions are not recognised in Hemerobiidae.

- 1 Fore wing without recurrent humeral vein ..... 2
- Fore wing with recurrent humeral vein ..... 4
- 2(1) Fore wing veins Sc and R widely spaced, linked by several crossveins; wings broad and bluntly rounded (fig 82) ..... *Psectra*
- Fore wing veins Sc and R close together throughout their lengths, with basal crossvein only; wings rather narrow ..... 3
- 3(2) Fore wing with three–five Rs veins (fig. 76) ..... *Micromus*
- Fore wing with two Rs veins, a crossvein from R to anterior fork of basal Rs vein (fig. 83) ..... *Zachobiella*
- 4(1) Fore wing tapered to narrow apex, usually falcate .... 5
- Fore wing not strongly tapered or falcate ..... 6
- 5(4) Fore wing relatively broad, with two series of gradate veins (fig. 77) ..... *Drepanacra*
- Fore wing relatively narrow, with three series of gradate veins (fig. 80) ..... *Megalomina*
- 6(4) Fore wing without crossvein from vein R to basal branch of Rs (fig. 81) ..... *Psychobiella*
- Fore wing with crossvein from vein R to basal branch of Rs ..... 7
- 7(6) Basal branch of vein Rs forked near base; a crossvein from R to distal branch of Rs (fig. 78) ..... *Nothorobius*
- Basal branch of vein Rs now forked near base; no crossvein from R to distal branch of Rs (fig. 79) ..... \**Carobius*

### *Micromus* Rambur

This large cosmopolitan genus is represented by *M. tasmaniae* (Walker) (figs 85, 86), by far the most abundant and widely distributed Australian hemerobiid. It usually comprises around 90–95% of "random" collections of Hemerobiidae in Australia and is superficially recognisable by its long narrow wings. The northern \**M. timidus* Hagen is generally larger and the ectoproct of both sexes has an elongate ventral process. In *M. tasmaniae* the female ectoproct is simple and that of the male has only a short blunt process. *M. tasmaniae* has been captured commonly throughout Tasmania.

### *Zachobiella* Banks

This small Australian/Oriental genus contains three species in Australia. The most common of these and the only

Tasmanian species, *Z. submarginata* Esben-Petersen (figs 93, 94), seems to be generally rare, though widely distributed through eastern Q, NSW and V. It closely resembles \**Z. lobata* New (WA), but genitalia of both sexes are distinctive.

#### *Psectra* Hagen

Five species of this widely distributed genus are known from Australia, of which *P. nakaharai* New (figs 95, 96) occurs in Tasmania (also NSW). *P. nakaharai* lacks the dark fore wing band of \**P. obliqua* (Banks) (Q, NSW) and is most similar to \**P. tillyardi* (Kimmins) (Q, NSW) in having the fore wings very finely mottled with pale grey to greyish brown, rather than with more discrete patches of shading. These two species differ markedly on features of the abdominal apex: (1) in *P. nakaharai* the median process from male tergite VIII is much shorter than in \**P. tillyardi*; (2) the female sternite VII of *P. nakaharai* is medially excavated, unlike \**P. tillyardi*. They appear to be closely related.

#### *Drepanacra* Tillyard

Now contains only *D. binocula* (Newman) (figs 87, 88), a falcate-winged species which is individually very variable in details of wing pattern and coloration. Historically many of the "varieties" have been treated as distinct taxa, with many names applied — including the variety *tasmanica* Tillyard to a dark-winged Tasmanian form. These variations were all recognised as conspecific by Tillyard (1923). *D. binocula* is common and widely distributed throughout Australia (except NT) and New Zealand, but appears to be most abundant in woodlands and forests in the southeast. Some individuals

superficially resemble examples of the following taxon, but differ in the number of gradate series.

#### *Megalomima* Banks

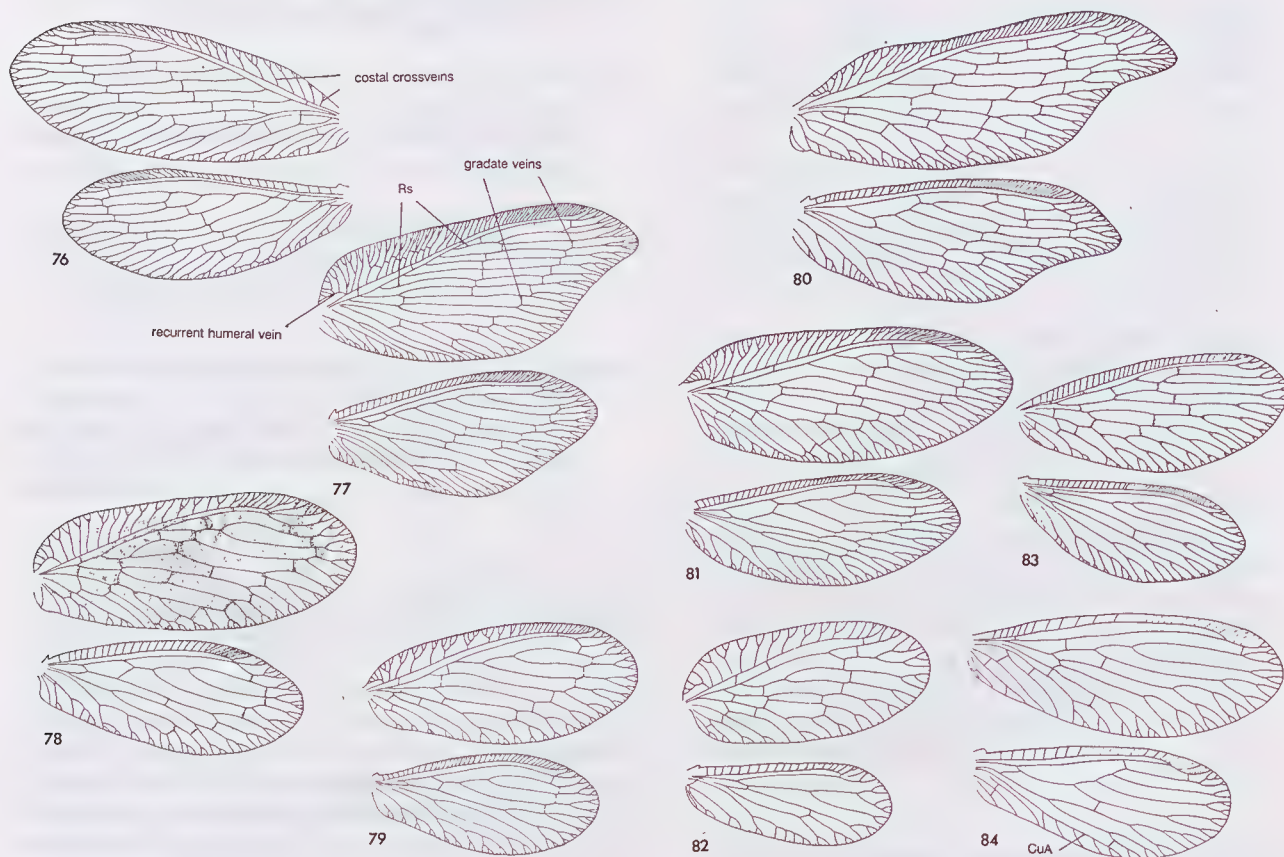
Another Australian endemic genus, containing three superficially rather different species which were placed in separate genera until recently (New 1988). *M. berothoides* (McLachlan) (figs 91, 92) differs from the other two in having clearly falcate fore wings, and occurs sporadically throughout southeastern Australia. I have seen few Tasmanian examples.

#### *Psychobiella* Banks

*Psychobiella*, also confined to the Australian region, contains two species of rather large dark Hemerobiidae with rounded wings. *P. sordida* (Banks) (also known as *P. fusca* Tillyard — synonymised by New 1988) (figs 89, 90) differs from \**P. occidentalis* New (SA, WA) in features of male terminalia, though the females are virtually identical in appearance. In *P. sordida* (known from Q, NSW, V as well as Tasmania), the male ectoproct is tapered ventrally rather than hooked, and the parameres have a strong ventral hook. It seems to be rather rare, but has been captured in small numbers in woodland environments and at light.

#### *Notherobius* New

This genus has been differentiated only recently from \**Carobius* Banks by New (1988), although the wing venations of the two genera are distinctive. The three species are all known only from the southeast, and the single Tasmanian



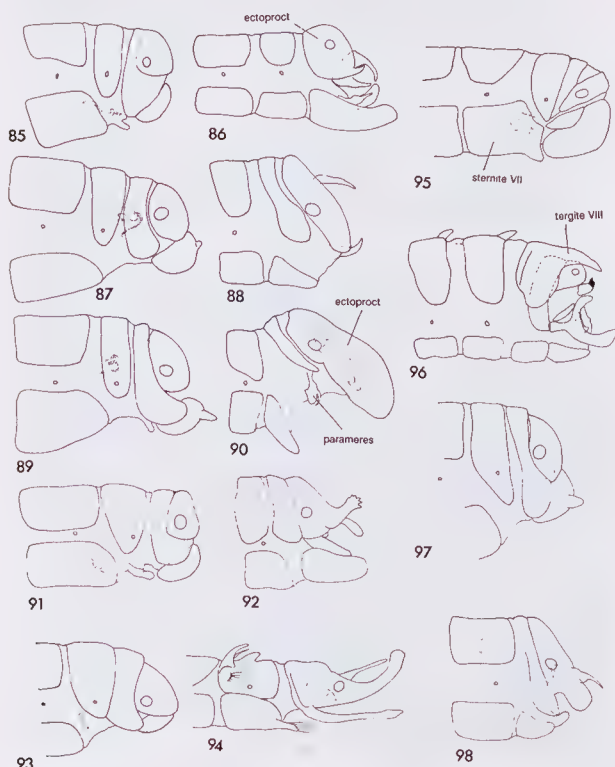
FIGS 76–84 — Hemerobiidae, fore and hind wings: 76, *Micromus tasmaniae*; 77, *Drepanacra binocula*; 78, *Notherobius nothofagi*; 79, *Carobius* sp.; 80, *Megalomima berothoides*; 81, *Psychobiella sordida*; 82, *Psectra nakaharai*; 83, *Zachobiella submarginata*; 84, (*Sisyridae*) *Sisyra* sp.

representative, *N. nothofagi* New (figs 97, 98), is separable from the others by the crossvein from the basal branch of fore wing vein Rs meeting the base of the distal branch of Rs, rather than R before the origin of the distal branch. It is known also from Victoria and has been taken predominantly in upland wet forest environments, including *Nothofagus*.

### Chrysopidae

The "green lacewings" or "golden eyes", are a cosmopolitan family (except for New Zealand), with nearly 2000 species recognised worldwide. Slightly more than 50 are known from Australia, of which seven (? eight) occur in Tasmania. Two species of the primitive subfamily Nothochrysinæ are included, one being a Tasmanian endemic.

- 1 Fore wing with jugal lobe present; vein Psm merges with inner gradate series; vein Psc merges with outer gradate series (fig. 99) ..... (Nothochrysinæ) ..... 3  
..... *Dictyochrysa*
  - Fore wing with jugal lobe reduced or absent; vein Psm relatively straight, merges with outer gradate series (fig. 101) ..... (Chrysopinæ) . 2
- 2(1) Fore wing costal cell broadened abruptly at base (fig. 100). ..... 3
  - Fore wing costal cell narrow at base (fig. 101) ..... 4



FIGS 85–98 — Hemerobiidae, genital features (85, 87, 89, 91, 93, 95, 97, female; 86, 88, 90, 92, 94, 96, 98 male), apex of abdomen, lateral: 85, 86, *Micromus tasmaniae*; 87, 88, *Drepanacra binocula*; 89, 90, *Psychobiella sordida*; 91, 92, *Megalomima berothoides*; 93, 94, *Zachobiella submarginata*; 95, 96, *Psectra nakaharai*; 97, 98, *Nothorobius nothofagi*.

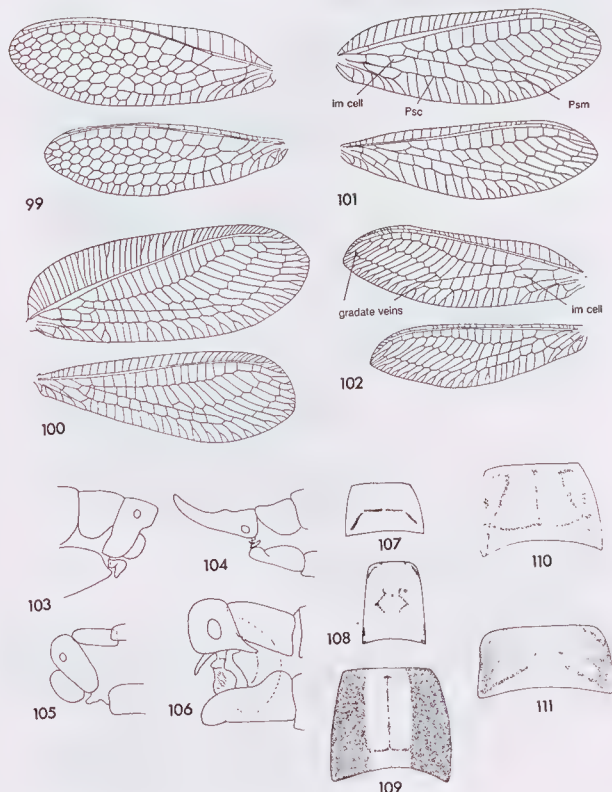
- 3(2) Fore wing im cell subtriangular ..... (*Ankylopteryx*)
  - Fore wing im cell subquadrangular ..... *Nothancyla*
- 4(2) Fore wing im cell subtriangular (smaller, relatively delicate species) (fig. 101) ..... *Chrysopa* s.l.  
(Species were allocated to *Apertochrysa* Tjeder and *Mallada Navas* by Brooks & Bernard 1991).
  - Forewing im cell subquadrangular (fig. 102) (larger, robust species) ..... *Italo-chrysa*

### Nothochrysinæ

#### *Dictyochrysa* Esben-Petersen

Differs from the other endemic Australian nothochrysinæ genus, \* *Triplochrysa* Kimmins, by having at least five irregular series of gradate veins, rather than three defined series. The three species are all Bassian.

- 1 Thorax with ivory midline, darkened along sides to give broad brown lateral stripes (fig. 109) ..... *D. latifascia*
  - Thorax not as above: if pale near midline, lateral borders not strongly darkened ..... 2
- 2(1) Pterothorax pale brown (face usually patterned; pronotum with strongly contrasted pattern: fig. 110) ..... *D. peterseni*
  - Pterostigma very dark brown (face not patterned; pronotum predominantly dark brown, traces of pattern) ..... \* *D. fulva*



FIGS 99–111 — Chrysopidae, fore and hind wings: 99, *Dictyochrysa* sp.; 100, *Nothancyla verreauxi*; 101, *Chrysopa* sp.; 102, *Italo-chrysa* sp.; 103, female, apex of abdomen, lateral of *N. verreauxi*; 104, same, male; 105, same, female of *Ankylopteryx pallida*; 106, same, male; pronotal patterns: 107, *C. ramburi*; 108, *C. edwardsi*; 109, *D. latifascia*; 110, *D. peterseni*; 111, *I. insignis*.

*D. latifascia* Kimmins is known only from Tasmania. *D. peterseni* Kimmins is the most widespread species in the genus (WA, SA, Q, NSW, V as well as Tasmania) and some dark individuals may be difficult to separate from \* *D. fulva* Esben-Petersen (Q, NSW, V).

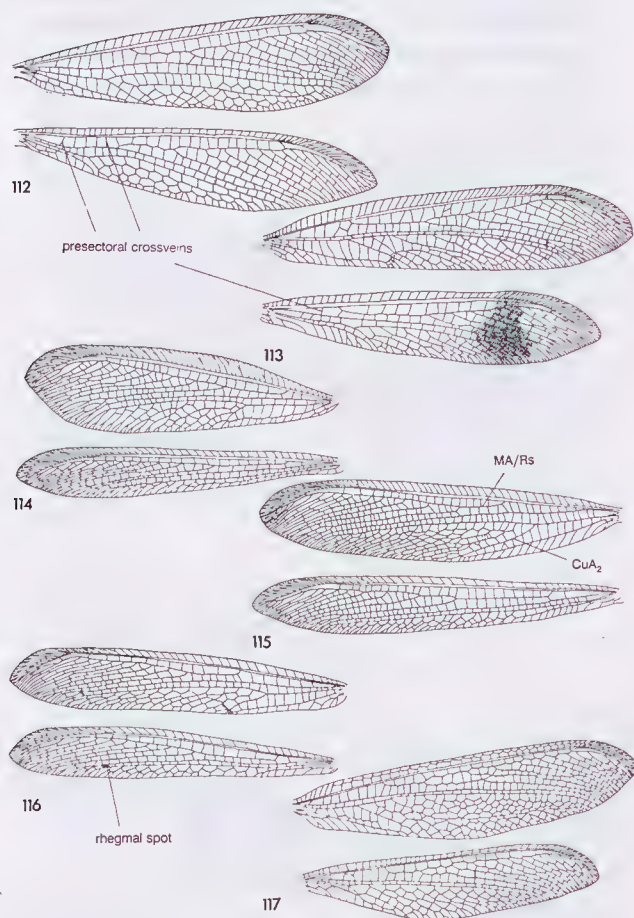
## Chrysopinae

### (\*) *Ankylopteryx* Brauer

A predominantly tropical genus. Its incidence in Tasmania is anomalous and needs verification, as it is not otherwise known from the southern half of Australia. *A. immaculata* Brauer has not been recorded since it was described in 1864, and it is possible that it is conspecific with the taxon now known as *Nothancyla verreauxi* Navas, which differs in wing venation mainly on the form of the im cell.

### *Nothancyla* Navas

A monobasic genus with a single Bassian species (*N. verreauxi* — figs 103, 104) which apparently does not extend to Q. It is unusual in lacking the basal subcostal crossvein and in the greatly elongated ectoproct and tergite IX of the male. Found in forested environments.



FIGS 112–117 — *Myrmeleontidae*, fore and hind wings: 112, *Myrmeleon acer*; 113, *Glenoleon falsus*; 114, *Mossega indecisa*; 115, *Escura australis*; 116, *Bandidus vafer*; 117, *Heoclisia fundata*.

### *Italochrysa* Principi

A widely distributed genus containing nine Australian species, which are almost all endemic. *I. insignis* (Walker) (figs 102, 111) is by far the most common of these, occurring throughout the country. The pronotal pattern (with the opposed “E” marks) is distinctive, although it is somewhat variable in intensity. *I. insignis* is the largest and most “robust” Tasmanian chrysopid.

### “*Chrysopa* Leach s.l.”

This is regarded as a “holding genus” to which a vast array of species has been uncritically referred, and its use here follows New (1980). This has now been outdated by the thorough generic revision of Chrysopidae by Brooks & Barnard (1990) but, as generic separations rely on genitalic features to a large extent, the key does not include these. Three species are known from Tasmania (of 25 currently included in this complex in Australia), and a fourth, one of the most common species throughout mainland Australia, is included in the following key.

- 1 An elongate black interantennal spot and 2 pronounced black vertex patches; prothorax unmarked ..... *Mallada tripunctata*
- Vertex unmarked, or pronotum with black markings behind anterior region ..... 2
- 2(1) Dorsum of prothorax not patterned with black; usually with small lateral black mark beneath anterolateral margin (with or without dark genal spot: if this is present, vertex may also be darkened) ..... *Mallada signata*
- Dorsum of thorax with discrete black streaks clearly visible from dorsal surface ..... 3
- 3(2) Pronotum with laterally opposed sinuous “V” marks each side of midline (fig. 108) .. *Apertochrysa edwardsi*
- Pronotum with central transverse streak each side of midline (fig. 107) ..... \* *Plesiochrysa ramburi*

*M. signata* (Schneider) is the most common species of Chrysopidae in Australia, though relatively few examples from Tasmania have been seen. It is rather variable in body markings, especially those on the vertex, and some specimens are almost as heavily marked as *M. tripunctata* (McLachlan). *M. signata* normally has a well-defined medial stripe along the scape, in addition to the external streak of both these species. The two species appear to be very closely related. *M. tripunctata* is also widespread on the Australian mainland, but is not as abundant as *M. signata*.

*A. edwardsi* (Banks) is a widespread Bassian species, and appears to be the most abundant chrysopid in Tasmania. It is related to \* *A. punctithorax* (New) (ACT) in general form but differs in details of body markings.

\* *P. ramburi* (Schneider), a very common species elsewhere in Australia, may well occur in Tasmania. The pronotal markings are diagnostic.

## \*Psychopsidae

One species of \* *Psychopsis* Newman, \* *P. mimica* Newman, occurs widely across southern Australia, but is rare in Victoria. It is unlikely that it would have been overlooked in Tasmania, but it is noted here for reference. Comparative details are given by New (1989a).

## Nymphidae

This family is restricted to Australia and the New Guinea region and is divisible into two discrete groups of genera, formerly separated at the family level as Myiodactylidae and Nymphidae. The former have broader wings and lack tibial spurs, whereas the latter (generally larger) have relatively elongate wings and short tibial spurs. Larvae of the former group are circular, flattened, "ambushing" arboreal insects, whereas known representatives of the latter are active ground and litter dwellers with the form shown in figure 16. No broad-winged forms, which are presumed to be the more primitive members of this archaic family, have been recorded from Tasmania. The sole recorded species in Tasmania, *Nymphes myrmeleonides* Leach (figs 136, 137), is amongst the largest Tasmanian lacewings (FW 28–42 mm), and tawny brown and black, with the apical region of the wings having a conspicuous white mark. It is widely distributed in eastern Australia. The body coloration and white wing mark allies *N. myrmeleonides* with *\*N. paramyrmeleonides* New (Q). The latter has the fore wing CuA fork beyond the separation of vein MA from Rs, whereas the fork is clearly basal to the separation in *N. myrmeleonides*.

## Myrmeleontidae

The "antlions" are the largest family of Neuroptera. About 2000 species are known, with more than 210 from Australia — nearly all of them endemic.

Higher classification of Myrmeleontidae has been based almost entirely on adult features, particularly those of wing venation, and the precise status of groups variously allocated as subfamilies or tribes is sometimes debatable. Three major groups occur in Australia: *\*Stilbopteryginae* are an endemic group absent from Tasmania, but representatives of both Myrmeleontinae (tribes Myrmeleontini, Dendroleontini, Distoleontini) and Acanthaclisinae occur there.

The following key, based on New (1985a) separates these groups.

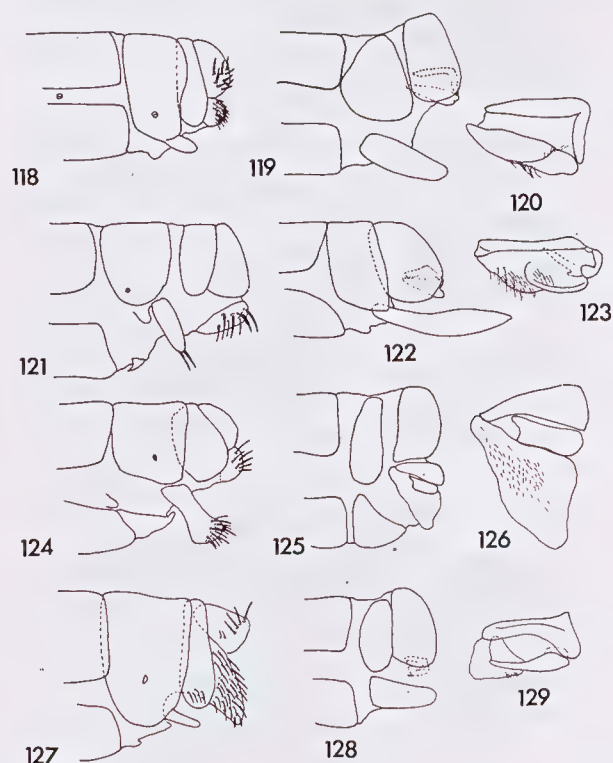
- 1 Vein 1A in hind wing with five or more branches; antennae short, strongly clubbed (very large species) ..... *\*Stilbopteryginae*
- Vein 1A in hind wing never with more than three or four branches; antennae, if short, not strongly clubbed or species smaller ..... 2
- 2(1) Femoral sense hair now present on hind leg (usually now densely hairy; one–six presectoral crossveins in hind wing, if more than two, fore wing costal cells simple except (rarely) immediately before pterostigma; legs usually slender, spurs and claws various) ..... (Myrmeleontinae) .. 3
- Femoral sense hair present on hind leg (large, densely hairy; more than four presectoral crossveins in hind wing; fore wing costal cells partially or wholly biareolate [fig. 117]; legs short and stout, spurs and tarsal claws very strongly arched) ..... Acanthaclisinae
- 3(2) Fore wing vein 2A clearly separable from 1A at base; 2A and 3A linked by crossvein or meeting at a point (figs 113, 114) ..... Dendroleontini

- Fore wing vein 2A close to 1A at base; 2A and 3A closely associated along central length ..... 4
- 4(3) Hind wing vein Rs arising opposite or beyond medial fork; usually four or more hind wing presectoral crossveins (fig. 112). ..... Myrmeleontini
- Hind wing vein Rs arising well before medial fork; one (rarely two or more) hind wing presectoral crossveins ..... 5
- 5(4) Fore wing veins CuA<sub>2</sub> and (CuP+1A) elongated, parallel to CuA<sub>1</sub> and hind margin of wing for considerable length (fore wing costal cells sometimes partially biareolate) ..... *\*Protoplectrini*
- Fore wing veins CuA<sub>2</sub> and (CuP+1A) not as above, short (fore wing costal cells simple) ..... *Distoleontini*

## Myrmeleontinae

The predominant subfamily in Australia, with 185 species at present described.

Myrmeleontini is represented in Tasmania by a "typical antlion" of the genus *Myrmeleon* L., *M. acer* Walker (figs 118, 120), which is common and widespread throughout Australia and may extend elsewhere in the western Pacific region. *Myrmeleon* is one of three genera of the tribe in Australia and contains 20 described Australian species. *M. acer* belongs to a group of dark-bodied species with unmarked wings, pronotum without a median stripe and frons largely



FIGS 118–129 — *Myrmeleontidae*, genitalic structures (118, 121, 124, 127, female, remainder male); each trio of figures is female, apex of abdomen, lateral; male, apex of abdomen, lateral; male, genitalic complex, lateral: 118–120, *Myrmeleon acer*; 121–123, *Mossegia indecisa*; 124–126, *Glenoleon falsus*; 127–129, *Escura australis*.

black. It most resembles *\*M. regularis* (Esben-Petersen), but has a slightly more complex fore wing venation and the posterior of the clypeus is usually blackened, rather than pale.

Dendroleontini is the largest antlion tribe in Australia (New 1985b). Single species of two genera occur in Tasmania. These genera are separable on numerous features and are distinguished by the following key, in which the very diverse mainland genus *\*Austrogymnocnemis* Esben-Petersen is also included.

- 1 Tibial spurs absent ..... *\*Austrogymnocnemis*
- Tibial spurs present ..... 2
- 2(1) Tarsal claws opposable on last tarsal segment ..... *Mossega*
- Tarsal claws not opposable on last tarsal segment ..... *Glenoleon*

#### *Glenoleon* Banks

A complex of 31 Australian species, which may eventually need generic subdivision. The single Tasmanian species, *G. falsus* (Walker) (figs 124–126), is widespread on the mainland and belongs to a group of relatively large species (FW around 25 mm or more) with a conspicuous black hind wing band. The fore wing is rather narrow, in contrast to

other banded hind wing species such as the northern *\*G. conspersum* Banks, and more resembles that of *\*G. secula* New (NT, WA). *\*G. pulchellus* (Rambur), with two black bands across the hind wing, occurs throughout eastern Australia, including southern Victoria, and could possibly occur in Tasmania.

#### *Mossega* Navas

A genus of four species, three of which are northern. *Mossega indecisa* Banks (figs 121–123) is very variable, and the name may be applied currently to a group of sibling species. The hind wing is both longer and narrower than the fore wing and the fore wing costal crossveins may be largely or irregularly biareolate. It occurs in many parts of Australia.

Distoleontini are also well represented in Australia (New 1985c). Only two species, in different genera, occur in Tasmania but, as the most abundant distoleontine in Australia (*\*Distoleon bistrigatus* (Rambur)) occurs on Mornington Peninsula in Victoria and in southern SA, *\*Distoleon* is also included in the following key.

- 1 Fore wing vein  $CuA_2$  long, reaching hind margin of wing opposite, or beyond, separation of MA from  $R_s$  (fig. 115) ..... *Escura*
- Fore wing vein  $CuA_2$  shorter, reaching hind margin of wing well before separation of MA from  $R_s$  ..... 2
- 2(1) Tibial spurs extending to about apex of  $t_2$ , always beyond apex of  $t_1$  (if longer — non-Tasmanian species — male parameres now elaborated or hooked, and species generally slender ..... *Bandidus*
- Tibial spurs very long, extending to or beyond apex of  $t_4$  (male parameres fused and strongly hooked, sturdy species) ..... *\*Distoleon*

*\*Distoleon* Banks contains three, possibly four Australian species.

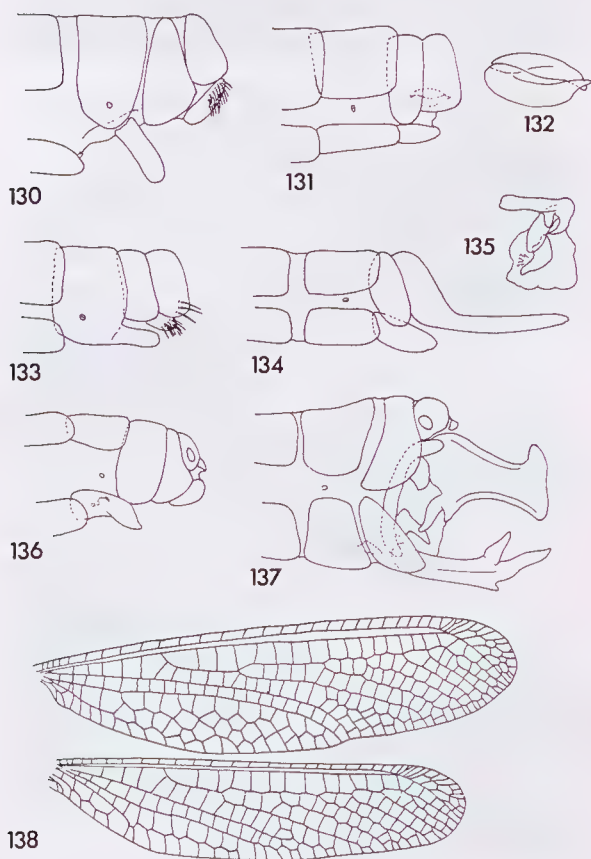
*\*D. bistrigatus* is large (FW 35–40 mm), and the pointed hind wing has an oblique preapical black or dark-brown streak. Other species are considerably smaller.

#### *Escura* Navas

Nine Australian species, of which *E. australis* (Esben-Petersen) (figs 127–129) is one of the largest (FW 30–36 mm) and is known also from NSW and V. It lacks conspicuous fore wing streaks, but has many distal gradate veins shaded. It thus resembles (\*) *E. divergens* Navas (known only from the type: “Australia”) but differs from it in having the central abdominal tergites with conspicuous ivory or yellow markings rather than just the posterior rim pale.

#### *Bandidus* Navas

A large complex of rather varied species, with 36 species described in Australia. The single species known from Tasmania, *B. vafer* (Walker) (figs 130–132), appears to be confined to the eastern Bassian province and is usually rather larger (FW 24–34 mm) than many of its congeners. The fore wing markings are diffuse, with only the distal radial gradate crossveins shaded and no distinct preapical fore wing streak or cubital mark. The frons does not have dense white hairs (as does *\*B. canifrons* Navas: SA, Q, NSW, V, which also usually has a large fore wing cubital spot). The hind wing has a distinct rhegmal spot (unlike *\*B. nigrifrons* Navas: “Australie”) and *B. vafer* differs from *\*B. cornutus* New (V) in having the central abdominal tergites black with a narrow, yellow



FIGS 130–138 — Myrmeleontidae, Nymphidae, Ascalaphidae. 130–135, Myrmeleontidae, notation as figures 118–129. 130–132, *Bandidus vafer*; 133–135, *Heoclis fundata*; 136, 137, Nymphidae: *Nymphes myrmeleonides*: apex of abdomen, lateral: 136, female; 137, male; 138, *Suhpalacsa* sp.: Ascalaphidae fore and hind wings.

posterior border rather than with yellow spots each side of the midline.

### Acanthaclisinae

Four genera, with 16 described species, occur in Australia (New 1985c). The single Tasmanian representative belongs to the largest of these, separable from \**Cosina* Navas by having many fewer hind wing presectoral crossveins (5–8 cf. 11–20) and hind wing Rs arising about one-quarter wing length rather than more distally.

#### *Heoclisis* Navas

*Heoclisis fundata* (Walker) (figs 133–135) is very widely distributed in Australia and it is rather variable. It has a pronounced median dorsal black pronotal stripe and is a large species (FW 40–50), commonly found in sandy areas. In *Heoclisis* the fore wing costal crossveins are linked along the prestigmal length of the costal cell.

### \*Ascalaphidae

Not known from Tasmania. All Australian Ascalaphidae (36 described species) belong to the subfamily Ascalaphinae, in which the large eyes are divided horizontally by a well-defined sulcus (New 1984). Only four species are known from Victoria, none being common there, and it is rather unlikely that they will be found in Tasmania.

### ACKNOWLEDGEMENTS

Mr Evan Schmidt kindly collected a large number of Tasmanian lacewings during his recent work on Tasmanian Psocoptera. I am also grateful to the curators of major insect collections in Australia for allowing me to utilise records from Neuroptera in their care. Dr C.N. Smithers kindly commented on a draft of this account.

### REFERENCES

- BROOKS, S.J. & BARNARD, P.C., 1990: The green lacewings of the world: a generic review (Neuroptera: Chrysopidae). *Bull. Br. Mus. nat. Hist. (Ent.)* 59: 117–286.
- CANARD, M., SEMERIA, Y. & NEW, T.R. (Eds), 1984: *BIOLOGY OF CHRYSOPIDAE*. W. Junk, Dordrecht.
- LAMBKIN, K.L., 1986a: A revision of the Australian Mantispidae (Insecta: Neuroptera) with a contribution to the classification of the family. I. General and Drepanicinae. *Aust. J. Zool. Suppl.* 116: 1–142.
- LAMBKIN, K.L., 1986b: A revision of the Australian Mantispidae (Insecta: Neuroptera) with a contribution to the classification of the family. II. Calomantispinae and Mantispinae. *Aust. J. Zool. Suppl.* 117: 1–113.
- LAMBKIN, K.L., 1986c: The Australian Mantispidae (Neuroptera): supplementary notes. *Gen. appl. Ent.* 19: 11–14.
- MEINANDER, M., 1972: A revision of the family Coniopterygidae (Planipennia). *Ann. zool. Fennica* 136: 1–357.
- MEINANDER, M., 1990: The Coniopterygidae (Neuroptera, Planipennia). A check-list of the species of the world, descriptions of new species and other new data. *Acta zool. Fennica* 189: 1–95.
- NEW, T.R., 1980: A revision of the Australian Chrysopidae (Insecta: Neuroptera). *Aust. J. Zool. Suppl.* 77: 1–143.
- NEW, T.R., 1981: A revision of the Australian Nymphidae (Insecta: Neuroptera). *Aust. J. Zool.* 29: 707–750.
- NEW, T.R., 1983: A revision of the Australian Osmylidae: Kempyninae (Insecta: Neuroptera). *Aust. J. Zool.* 31: 393–420.
- NEW, T.R., 1984: Revision of the Australian Ascalaphidae (Insecta: Neuroptera). *Aust. J. Zool. Suppl.* 100: 1–84.
- NEW, T.R., 1985a: A revision of the Australian Myrmeleontidae (Insecta: Neuroptera). I. Introduction, Myrmeleontini, Protoplectrini. *Aust. J. Zool. Suppl.* 104: 1–90.
- NEW, T.R., 1985b: A revision of the Australian Myrmeleontidae (Insecta: Neuroptera). II. Dendroleontini. *Aust. J. Zool. Suppl.* 105: 1–170.
- NEW, T.R., 1985c: A revision of the Australian Myrmeleontidae (Insecta: Neuroptera). III. Distoleontini and Acanthaclisinae. *Aust. J. Zool. Suppl.* 106: 1–159.
- NEW, T.R., 1988: A revision of the Australian Hemerobiidae (Insecta: Neuroptera). *Invertebr. Taxon.* 2: 339–411.
- NEW, T.R., 1989a: The Psychopsidae (Insecta: Neuroptera) of Australia and the Oriental Region. *Invertebr. Taxon.* 2 (1988): 841–883.
- NEW, T.R., 1989b: The genus *Oedosmylus* (Insecta: Neuroptera: Osmylidae). *Invertebr. Taxon.* 3: 135–148.
- NEW, T.R., 1991: Neuroptera (lacewings). In *THE INSECTS OF AUSTRALIA*. Melbourne University Press: 525–542.
- RIEK, E.F., 1970: Neuroptera (lacewings). In *THE INSECTS OF AUSTRALIA*. Melbourne University Press: 472–494.
- RIEK, E.F., 1974: The Australian moth-lacewings (Neuroptera: Ithonidae). *J. Aust. ent. Soc.* 13: 37–54.
- TILLYARD, R.J., 1923: Descriptions of new species and varieties of lacewings (Order Neuroptera, Planipennia) from New Zealand, belonging to the families Berothidae and Hemerobiidae. *Trans. Proc. NZ Inst.* 54: 217–225.

(accepted 9 August 1991)



## MOUNTAIN GEOMORPHOLOGY AND THE LAST GLACIATION AT LAKE ST CLAIR

by Kevin Kiernan

(with four text-figures)

KIERNAN, K.R., 1992 (31:x): Mountain geomorphology and the Last Glaciation at Lake St Clair. *Pap. Proc. R. Soc. Tasm.* 126: 47–57. ISSN 4703–0080. Department of Geography and Environmental Studies, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7000.

During the Last Glaciation, the glaciers that developed in the Lake St Clair area were largely controlled by the topography and played only a minor role in shaping the landscape, the most striking glacial features of which were produced during earlier glaciations. The glaciers were subject to continental influences, which resulted in some distinctive depositional and erosional landforms, but were still of essentially temperate type. In apparent contrast to those in the West Coast Range, the glaciers in the Lake St Clair area retreated systematically in clear stages.

**Keywords:** glaciation, palaeoclimate, Lake St Clair, Tasmania, geomorphology, landforms, till, cirque, glacial trough, mountains.

### INTRODUCTION

The scenery of the Lake St Clair area in the Cradle Mountain–Lake St Clair National Park owes much to past glaciation. Lake St Clair was formed by the Derwent Glacier downstream of the confluence of the Narcissus, Cephissus (Pine), Marion and Hamilton tributary glaciers (all of which arose in the Du Cane Range), where that glacier was joined by ice that moved westwards from the ice-abraded Central Plateau (Jennings & Ahmad 1957). This paper explores the glacial geomorphology of the upper catchment area of the Derwent Glacier (fig. 1). It also examines the uppermost reaches of the adjacent Murchison, Mersey and Nive valleys in an effort to identify the glacial divides during the Last Glaciation, known locally as the Cynthia Bay Glaciation (Kiernan 1985, 1991) and regarded as equivalent to the Margaret Glaciation of western Tasmania.

The area lies amidst some of Tasmania's highest mountains, the study area ranging in altitude from c. 1470 m in the Du Cane Range to c. 700 m south of Lake St Clair. These mountains consist of Jurassic dolerite that overlies Permian and Triassic sedimentary rocks of the Parmeener Supergroup (Banks 1973). Former erosion surfaces are conspicuous features of the landscape. Davies (1959) recognised five principal accordances, together with higher monadnocks. The most conspicuous surfaces are the St Clair Surface (730–825 m), which forms the plains south of Lake St Clair and the floors of some of the larger valleys, and the Lower Plateau Surface (915–1065 m) and Higher Plateau Surface (1200–1350 m) that are represented on the Central Plateau and Mt Olympus. The monadnocks form some of the higher summits, including Mt Geryon and the Acropolis in the Du Cane Range. The present daily median temperature at the southern end of Lake St Clair (735 m) is 7.95°C and annual precipitation totals about 1200 mm.

Moraines were first recognised in the area by Gould (1860) and the glacial origin of Lake St Clair was recognised by Officer *et al.* (1895). Clemes (1925) suggested that four glaciations had taken place, but Lewis (1939, 1945) argued that there had been only three glaciations. Subsequent studies on the adjacent Central Plateau prompted the conclusion that only one glaciation had occurred (Jennings & Ahmad 1957), while Derbyshire (1963) also interpreted glacial

deposits that occur downstream of Butlers Gorge as representing a single glaciation. However, Derbyshire (1967, 1968) later suggested that two glaciations had occurred. In other papers, Derbyshire described additional aspects of the glacial and periglacial geomorphology of the Lake St Clair area (Derbyshire 1965, 1968a, 1968b, 1971, 1972, 1973; Derbyshire *et al.* 1965). The most recent studies have increased the evidence for multiple glaciation of the area (Kiernan 1983, 1985, 1989, 1990a, 1991). Some previous researchers into past glacial environments and the effectiveness of glaciation as an agent of landscape change have interpreted all the landforms and sediments as the product of a single glaciation, the Last Glaciation (e.g. Peterson & Robinson 1969, Davies 1969). More recent studies (Kiernan 1985, 1991) have permitted the differentiation of features attributable to different glaciations (fig. 2), and this paper provides an assessment of the extent, impact and nature of the Last Glaciation.

### EROSIONAL LANDFORMS

A variety of erosional landforms occurs in the mountains of the Lake St Clair area (fig. 2). A composite valley-head cirque 3 km wide lies at the head of the Narcissus Valley. This cirque is floored by Permian sediments, and its headwall is cut in Triassic sandstone that is overlain by columnar dolerite. The pronounced scalloping of the north–south aligned ridge of Mt Geryon and the Acropolis, which forms the western margin of this cirque, indicates that this was a particularly important part of the Du Cane Range snowfence. Rock type has exerted a major control on the form of the cirques in this area. Whereas headward sapping of the Triassic sandstone beneath the dolerite columns has permitted the development of a steep 500 m-high headwall in the Narcissus Valley, the head of Cephissus Valley cut only in massive dolerite is steep and mammillated rather than vertical. A steep arête occurs between the two valleys. The floors of the Marion and Hamilton cirques are also cut in sedimentary rocks of the Parmeener Supergroup and, again, have vertical headwalls.

Each of these valley-head cirques has its floor at 900–950 m and a headwall 350–500 m high. Only in the Marion Cirque, where there is a small rock basin lake 13 m deep



FIG. 1 — Locality map of the Lake St Clair area, showing the catchment of the Derwent River above its confluence with the Travellers Rest River, and mountain areas adjacent to its headwaters. The numbers refer to sites at which weathering rind measurements were made.

(Derbyshire 1967), is there a clearly defined threshold. Several factors have limited the degree of cirque development and conditioned the character of these cirques: the inhibition of tributary ice flow into the very large trunk glacier (Hamilton Cirque); over-riding of the headwall and later some downwind interception of snow (Cephissus Cirque); an unfavourably aligned snowfence (Marion Cirque); and a low and broken valley head (Hamilton Cirque).

Geological structure has played a major role in cirque location. Lake Helen (1190 m) and Lake Enone (1210 m), the latter a rock basin, occupy two prominent cirques on a sandstone bench on the eastern flank of Mt Olympus (Derbyshire 1964, 1968a). A number of smaller cirques are also present at about the same altitude further north on this mountain. Preglacial topography, in the form of benches on which snow could accumulate leeward of the snowfences, is likely to have been a major determinant of their location (Peterson 1969).

A series of cirques occurs on the slopes of the Du Cane Range at the head of the Murchison and Mersey Valleys. They indicate that the range formed a major glacial divide between ice that flowed south to Lake St Clair, west into the Murchison Valley and north to the Mersey Valley. A shallow



FIG. 2 — Glacial geomorphology and sediments of the Lake St Clair area.

and totally enclosed cirque, 200 m in diameter, occurs on the summit of Massif Mountain. This has a distinct bedrock lip on the northern side. The cirque drains into a pit 15 m in diameter and 8 m deep which appears to be focussed on a major joint intersection. While the development of this curious streamsink may be due to very localised joint dilation, there is little evidence to support this. An alternative is that it is the product of solution processes acting upon autometamorphic alteration products in the joints (Hale 1958, Spry & Hale 1964).

Many cirques have been over-ridden, particularly on the Labyrinth Plateau (Derbyshire 1967). Cirques between Walled Mountain and Macs Mountain have been overridden by ice that was flowing to the east. Long Lake occupies a valley-head cirque that was overridden by ice from The Labyrinth. During the Last glaciation, the ice was less extensive and the Labyrinth ridge formed an important glacial divide for ice that flowed westwards into the Murchison Valley and eastwards into the Cephissus Valley. A cirque at 960 m on the southern end of Mt Olympus has been overridden by ice that passed through a diffuence col from the Cuvier Valley. Valley-head cirques that lie north and south of Mt Ida have both been overridden by ice from the Central Plateau where almost all the cirque headwalls have also been overridden by ice that flowed generally southwards and southwestwards (Jennings & Ahmad 1957).

Rock-basin lakes are abundant on both the Central Plateau and the Labyrinth Plateau. In both these localities, narrow elongate depressions follow structural lineaments in the dolerite and are linked by rectangular drainage systems (Jennings & Ahmad 1957). Some of the lakes in The Labyrinth are in excess of 10 m deep, while other basins such as Lake Helios are broad and shallow. Small rock basins formed transverse to the local flow of ice occur 450 m above Long Lake on the western slopes of the Parthenon.

The most outstanding of the rock-basin lakes is Lake St Clair. This piedmont lake occupies four rock basins on the floor of a glacial trough. Its maximum depth of 167 m (Derbyshire 1971) makes Lake St Clair probably the deepest lake in Australia. Less than 50 m of this depth is due to impounding by end moraines. The deepest basin lies downstream of the entry point of the Ida glaciers from the Central Plateau. A fifth basin lies at the southeastern extremity of Lake St Clair and was developed jointly by the glacier that flowed into the northern end of Lake St Clair and ice that descended from the Traveller Range. A rock bastion, Fergies Hill, forms the northern boundary of this basin. Sublacustrine benches along the lake margins may be of lithological origin. Derbyshire (1971) suggests 76.8% of the total lake volume of 1.69 km<sup>3</sup> is contained within the rock basins. The lake bed lies at a lower altitude than the bed of the Derwent River as far downstream as the limit of continuous glacial drift, 8 km southeast of Butlers Gorge.

The bedrock geometry and preglacial topography have clearly been responsible for determining the location of the glacial troughs. South of Mt Ida, the Lake St Clair trough is bounded by dolerite to the east and subhorizontal sedimentary rocks to the west. The base of the dolerite lies over 300 m above the lake on Mt Olympus but descends below lake level at the foot of the Traveller Range which raises the possibility that the trough may exploit a fault. The orientation of structural lineaments in the dolerite of the Central Plateau is duplicated in the orientation of the tributary valleys upstream from Lake St Clair, which suggests that these valleys have been superimposed from the dolerite (Jennings and Ahmad 1957). Because the major erosion surfaces (Davies 1959) predate the glaciations, the suggestion that the principal valleys have been superimposed carries with it the corollary that the broad topography of the area is essentially the product of fluvial erosion.

Broad U-shaped troughs are well developed in sandstone and mudstone. In contrast, narrower troughs are cut in dolerite and descend to the St Clair Surface from the Central Plateau and at the head of the Cephissus Valley. The Lake

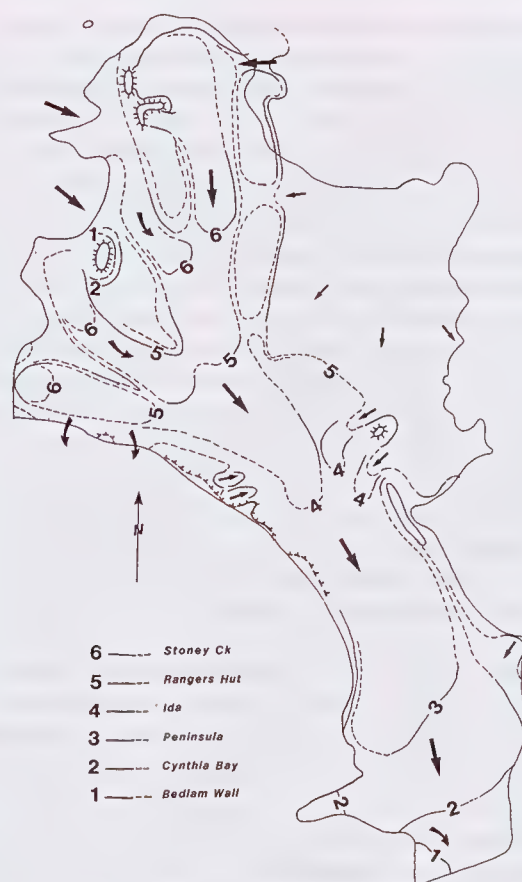


FIG. 3 — Principal ice limits during different phases of glaciation in the Lake St Clair area: scale as figure 1.

St Clair trough is strongly asymmetric and has a steep western wall. The deepest part of the lake occupies a steep, straight trench that trends NNW–SSE close to the western shoreline. This is cut in Triassic rocks. At this point, the rock bastion of Fergies Hill deflected the ice flow westward towards a re-entrant in Parmeener rocks, where the Cuvier Valley joins the St Clair trough. The rock bastion probably owes its origin largely to interference with the flow of the Derwent Glacier by ice that spilled over the margin of the Central Plateau. Therefore, the most marked over-deepening of the trough may not reflect the amount of ice that descended from the Central Plateau so much as its energy, and its interference with the main ice flow southwards (cf. Derbyshire 1971).

Du Cane Gap is a transfluence col through which ice escaped southwestwards from the Mersey Valley into the head of the Narcissus trough. A further col occurs between Mt Ossa and Mt Massif, and ice-abraded rock surfaces indicate that ice flowed eastwards through this from the upper Murchison catchment, where a very large volume of ice accumulated (Kiernan 1990a), into the Mersey Valley, which broadens appreciably downstream. However, moraine ridges that are concave to the east were constructed east of this col during the most recent phase of glaciation and indicate that diffuence through the col did not occur at that time. Cols between Mt Olympus, Mt Byron and Mt Cuvier exhibit stoss and lee features, which indicate that ice moved southwards through them from the Hamilton Valley into the Cuvier Valley. Similar evidence indicates that ice from the Cuvier moved into the St Clair trough through a col on Mt Olympus.

Ice-abraded bedrock indicates that the most recent glacial divide on the Central Plateau broadly coincided with the present divide between northward and southward flowing streams (Jennings & Ahmad 1957). Some of the generally southward-moving plateau ice spilled into Lake St Clair. Selective erosion along joints in the dolerite is common. Stoss and lee surfaces on summits in the southern part of the Du Cane Range suggest that ice flowed from the upper Murchison into the Cephissus Valley. However, roches moutonnées at lower levels north of the Parthenon suggest that, at a later date, ice flowed from the Labyrinth into the head of the Murchison Valley.

Smoothed bedrock on the summit of Walled Mountain suggests that it may have been overridden by ice in the upper Murchison catchment when the glaciers were most extensive. These summit rocks, together with other abraded dolerite surfaces at 1250 m on the eastern ridge of Walled Mountain, are exfoliating in slabs 0.05–0.2 m thick. Glacial erosion may also have played a significant role in stripping overlying rocks from the lithological benches of Triassic sandstone developed on Mt Gould and Mt Olympus.

Glacial striae are generally poorly preserved, due to the susceptibility of the rocks to chemical weathering. However, numerous striations on dolerite one metre below the normal water level of Lake Helios indicate that ice moved northwards into the valley of the Wallace River, a tributary of the Murchison River. Striations that trend towards 190°–205° on sandstone bedrock just beneath the surface of a small tarn on the Mt Gould Plateau, together with plucking of nearby outcrops, indicates that the Cephissus Glacier flowed across the plateau from the north. The generally southward flow of this ice across the Marion and Hamilton valleys towards the cols at the head of the Cuvier is supported by bedrock plucking and one lunate fracture. Lake Helios undoubtedly contained ice during the most recent glaciation, but the possibility that the Gould Plateau striae are earlier forms which have been exhumed must be kept open (cf. England *et al.* 1981).

Meltwater has played a major role in initiating or deepening many of the present stream channels in the Lake St Clair area. Steep canyons incised in rock downstream of the higher cirques may have been initiated subglacially and have certainly been deepened as proglacial channels. Lateral meltwater flow along valley margins utilised lithological benches and also structural lineaments in the dolerite. As an example of the former, meltwater erosion has emphasised sandstone benches above Byron Gap and produced channels across the sandstone Gould Plateau. Deflection of meltwater along dolerite lineaments is evident above Long Lake, in The Labyrinth and on the Central Plateau. Some of the narrow elongate basins oriented parallel to the direction of ice flow on the Central Plateau may be the result of meltwater corrosion by subglacial streams (Fairbridge 1968).

The present outlet of the Derwent River from Lake St Clair was probably initiated subglacially on the eastern margin of the Derwent Glacier, where confining ice pressures were lowest (Derbyshire 1971), and probably was a proglacial channel cut through the drift before adopting its present form.

The eastern ridge of the Acropolis and the summit of Mt Gould consist of dolerite columns that have not been overridden by ice at any time. The lower limit of shattered rock on the Parthenon and Minotaur suggests that less than 50 m of ice passed through the adjacent cols during the most recent phase of glaciation.

Impressive free faces characterise many of the scarps in the Lake St Clair area, especially in the Du Cane Range and on Mt Olympus. While many of these have resulted from direct erosion by glaciers, some have resulted from the mechanical adjustment of rock materials to unloading or basal sapping in response to previous glacial erosion. On a small scale, such processes give rise to concentric shells such as are found on the summit rocks of Walled Mountain. Slopes formed on rocks with a high degree of structural anisotropy, particularly the vertically-jointed dolerite, are prone to fail due to joint dilation, once valley sides or cirque headwalls are steepened. The cambering and ultimate disintegration of columns due to this process of slab toppling (Caine 1982) is evident on Mt Olympus (Clemes 1925, Derbyshire 1973) and in the Du Cane Range where it has effected considerable local topographic change. The development of rock crevasses and dilation trenches that parallel the steepened slope is the first obvious sign of this process. Both are present above the Narcissus Cirque and on Mt Olympus. The process is not confined to dolerite terranes as rock crevasses and small gullies formed parallel to the valley sides also occur at 1100 m on the sandstone eastern slopes of Mt Gould. The "Big Gun" in the Du Cane Range west of Massif Mountain is a large leaning topple that has slipped downslope and is close to the point of outward collapse.

Toppling is most apparent in those areas where there has been glacial erosion of sedimentary rocks that underlie the dolerite. Unloading is probably the principal cause, but periglacial processes, including wedging by ice, snow and rocks, probably play a role in dislodging columns (Banks 1981, Derbyshire 1973). Removal of alteration products in joints may also be significant in some cases (Hale 1958). Some topples may be directly of glacial origin. Six metre high columns lean outwards at 30°–50° on the plateau margin just south of Mt Hyperion and have clearly been pushed by a small glacier that constructed a small blocky moraine against their foot.

Occasional fresh scars on dolerite cliffs and freshly broken rocks at their foot suggest that only limited erosion by rockfall is occurring at present. A large fresh scar on Falling Mountain delineates a recent collapse over an area of c.5 ha. Some steep eroded gullies between dolerite columns on Mt Geryon and Walled Mountain are probably the result of snow and rock avalanche. Snowpatch erosion occurs to a very limited extent, as on the northern end of Mt Olympus. It is far more effective on Triassic sandstone than on dolerite.

Solution pans have developed on the dolerite summit rocks of Walled Mountain (1411 m), and pans, runnels and sub-erratic pedestals are present on the Triassic sandstone benches of the Gould Plateau (1070 m). Present-day fluvial erosion is restricted largely to reworking of unconsolidated deposits. Some debris avalanching has occurred adjacent to a creek which descends steeply to the floor of Pine Valley southeast of the Parthenon, and landslide scars and hollows are common in areas of steeper terrain on Mt Olympus and elsewhere. Erosion runnels have developed on regolith bared by nivation in the Narcissus Cirque and on Mt Olympus. Small-scale erosion and collapse of stream-banks is widespread, as exemplified along the course of Cephissus Creek in Pine Valley.

Erosion scars and collapsed areas around parts of the Lake St Clair shoreline have resulted from the artificial raising of the lake level to facilitate generation of hydro-electricity. This has focussed erosion higher on the shore profile than

was naturally the case. Moreover, this exposure has opened the moraines to the operation of other erosional processes from which they would otherwise have been insulated by the presence of a vegetation or peat cover. These processes include sapping of the bared banks by groundwater discharge when drawdown of the lake water level occurs. Erosion due to the raised lake level has also caused retreat of the dunes at Frankland Beaches, which have been further eroded by sand quarrying and the construction of a road along their crest. Serious localised erosion has also occurred along walking tracks and in areas of the Central Plateau subject to repeated fires and sheep grazing.

## DEPOSITIONAL LANDFORMS AND SEDIMENTS

The distribution of depositional landforms and sediments is strongly influenced by the broad topographic framework of the area (fig. 2). The Central Plateau adjacent to Lake St Clair is dominated by erosional landforms (Jennings and Ahmad 1957). Few moraines are to be found there, which Davies (1969) suggested might be due to retreat having been gradual rather than episodic. The steep walls of the St Clair trough and the presence of Lake St Clair mean that glacial deposits are accessible only in the tributary valleys and beyond the southern margin of the lake. The principal end moraine complexes enable several phases in the Last Glaciation to be identified (fig. 3).

### Moraine Complexes

#### (1) Bedlam Wall moraine

The steep flanks of the Bedlam Wall ridge south of Lake St Clair have generally precluded the preservation of deposits but a lateral moraine extends along its foot at 830–840 m. At the northern end of the ridge it is overlain by 1 m of angular dolerite talus derived from a rock rib. The moraine can be traced southwards for nearly 2 km. An outwash plain downstream of the moraine can be traced upvalley inside the moraine limit.

The Bedlam Wall moraine marks a phase during which the Derwent Glacier terminated c. 3 km south of Lake St Clair, close to the site of the present Derwent Bridge settlement. The moraine is well preserved but the till is weathered to a depth of at least 1.2 m. Small till knobs south of Mt Olympus, sandstone erratics at 1040 m on the western side of the Parthenon, and a talus that formed in contact with an ice margin at 1260 m on the northeastern shoulder of Mt Gould all appear to lie c. 150 m above any of the more recent ice limits and may relate to this Bedlam Wall phase. The Bedlam Wall deposits generally lie inside the maximum ice limits suggested by the erosional topography but outside the succeeding Cynthia Bay moraines. The Bedlam Wall till was deposited during the Beehive Glaciation, which occurred prior to the Last Interglacial Stage (Kiernan 1985, 1991).

#### (2) Cynthia Bay moraines

An impressive array of at least 25 terminal moraine ridges and latero-terminal moraines bounds the southern shoreline of

Lake St Clair. The southernmost of these moraines is located 1 km from the lake shore and is believed to represent the terminus of the Derwent Glacier during the late Last Glacial Stage. These narrow and steep moraines do not exceed 10 m in height, and on average are spaced 50 m apart (fig. 4). Some can be traced almost continuously for 3.6 km. They were formed by the expanding foot of the Derwent piedmont glacier as it emerged from the St Clair trough. Given the short duration of the Last Glaciation in Tasmania (Kiernan 1983) and the likelihood that retreat of the ice occurred very rapidly, these moraines, and others of similar form that occur further upvalley, may represent annual fluctuations, although slightly longer periods could be involved.

His bathymetric survey of the southern end of the lake led Derbyshire (1971) to argue that surficial drift deposits 4.6 m thick occurred on a bench southeast of the main terminal basin, while drift deposits 1.8–5.4 m thick occurred in the southernmost basin of the main trough. His data suggest that the moraine barrage may be 40–45 m thick in the west, thinning to 24 m in the east. Recessional moraines occur to a depth of at least 30 m below the lake surface (Derbyshire 1971).

The steep distal faces of the moraines suggest that they were formed by advance of an active ice front. Steep end moraines of broadly equivalent age occur in some other locations, including the northern cirque of Mt Olympus, where a steep moraine 3–5 m high has obliquely overridden an earlier cirque moraine 10–15 m high.

Basal till is exposed in many places around the shoreline of Cynthia Bay. It is generally tough and fissile with a greenish-grey matrix. Individual clasts are faceted and striated clasts are common. Dolerite generally forms 70–80% of the clasts larger than small cobbles, with quartzite derived from the Parmeener sedimentary rocks accounting for the remainder. Clasts from the Parmeener sediments are more common in the pebble and granule grades.

Mechanical composition of some of the glacial and glaciofluvial deposits has been described by Derbyshire (1967, 1968a). Plagioclase feldspar, weathered dolerite mesostasis and quartz dominate the medium sand fraction, while X-ray diffraction analysis of the clay suggests that it is virtually unweathered and represents deposits produced primarily by mechanical fracture during transport by ice.

Ice contact stratified drift has been exposed by quarrying and road construction in the end moraine. Beds of gravel, sand, massive silts and clay dip upstream and balls of clay and sand that may have been transported in a frozen condition are also present. Slump structures are localised. These characteristics led Derbyshire (1965) to interpret the deposit as the result of the slow melting of inert, debris-charged ice. He envisaged that extensive slumping and melting of the ice had been impeded by an insulating cover of drift and effective subsurface drainage through the adjacent outwash plain. The end moraine represents a steady-state terminal position occupied for some time, the other moraines representing shorter time periods. Their regular spacing suggests that retreat of the ice front involved periodic halts at steady-state positions.

Bouldery ablation till, with angular dolerite clasts 2–3 m long in a loose and slightly oxidised matrix, caps many of the moraines. Boulders which protrude through some of the intermorainal outwash probably represent supraglacial ablation deposits or lag boulders that could not be removed by meltwater.

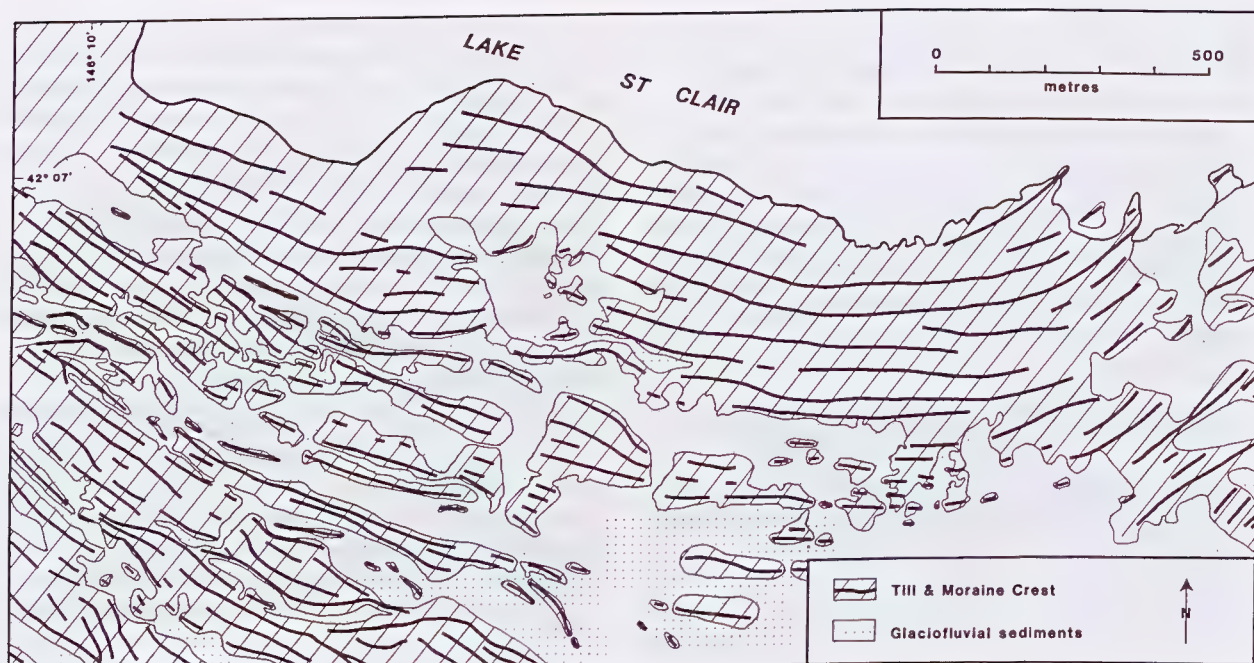


FIG. 4 — Moraine ridges in the Cynthia Bay area.

The coarser grades of the outwash gravels are dominated by dolerite, the finer grades by quartz. The dolerite cobbles are moderately well rounded and of moderate to high sphericity, but angularity increases in the finer grades, presumably due to water cushioning (Hatch *et al.* 1971, Blatt *et al.* 1972). The larger clasts occur in a loose-textured matrix which is commonly bright yellowish brown (10YR7/6). Sections cut by the Derwent River reveal foreset beds, truncated bedding and cross bedding indicative of seasonally torrential meltwater flow. Interbedded fine gravel, sand and silt lenses are common. Massive clays, either in the ice contact stratified drift or within intermorainal swales, are of glaciolacustrine origin.

The individual clasts in the moraines are little weathered and the soil profile can best be described as of A Cox C-type (Birkeland 1984). Nowhere do more than 0.3 m of slope deposits overlie the Cynthia Bay till. X-ray diffraction led Derbyshire to suggest that some kaolinite was present in the till matrix but the peak on his diffractograms is very close to background and has not been duplicated by analyses during the present study. All these characteristics suggest the Cynthia Bay till is considerably younger than the Bedlam Wall till. Its weathering characteristics compare closely to tills from elsewhere in Tasmania that are known to date from the late Last Glacial Stage (Kiernan 1983, 1990b).

### (3) Peninsula moraines

The rock bastion of Fergies Hill that extends westwards into the southern end of Lake St Clair is capped by a latero-terminal moraine that can be traced along the eastern side of the trough from 740–820 m. A minor recurved segment of lateral moraine from 760–840 m on the western side of the lake may correspond with the Peninsula Moraine and, if so, indicates that the surface of the ice sloped eastwards at 25–30 m/km. Such asymmetry of the ice surface is likely to have been promoted by shading and snowfence effects, but

it also suggests that little ice was entering the trough from the Central Plateau at this time.

The bathymetric chart suggests that the ice initially retreated to the western margin of the Derwent Basin and then to the southern margin of the deepest rock basin where it became grounded.

### (4) Ida moraines

Discontinuous lateral moraines descend to Lake St Clair from 800 m altitude beneath Mt Ida. These document the most recent occasion during which the Ida glaciers descended into the Lake St Clair trough. The moraines that were formed on the southern side of the North Ida Glacier are sharply recurved southwards, whereas lateral moraines of the Derwent Glacier occurring on its northern side appear to have been undisturbed by the Ida ice. This suggests that the largest of the glaciers to descend from the Central Plateau to Lake St Clair was deflected southwards by the Derwent ice.

Retreat of the main St Clair Glacier from the Ida limit may have occurred at a fairly uniform rate, as there is little evidence of end moraines for 4 km upstream, after which many end moraines occur in two principal groups.

### (5) Hamilton Valley moraines

A poorly developed interlobate complex of low moraines with an amplitude of less than 5 m occurs at the lower end of the Hamilton Valley. This complex indicates that the Hamilton Glacier was the next major tributary to withdraw from the main trunk glacier. Ground moraine with few definite moraine ridges is present on the floor of the Hamilton Valley. Hummocky drift occurs in a few localities and suggests that the ice flow ceased. There is no evidence to indicate continued confluence of the Marion and Hamilton ice after the Hamilton and Narcissus glaciers had separated.

These moraines have an amplitude of less than 6 m. A fan of outwash extends into the northwestern corner of Lake St Clair.

#### (6) Rangers Hut moraines

An interlobate complex of low moraines occurs near the huts at the northern end of Lake St Clair. A fan of outwash extends into the lake and glaciofluvial deposits at least 4 m thick also occur a short distance upstream from the huts. Small end moraine ridges and a limited amount of hummocky moraine occur at the mouth of the Narcissus Valley. A sharp, sinuous ridge in the axis of the valley 2.5 km north of Lake St Clair has the form of a small esker (E.A. Colhoun, pers. comm.). The western part of the Rangers Hut complex contains moraines that are concave towards the Marion and Cephissus valleys. Hence, this interlobate complex documents the separation of the three glaciers.

Withdrawal of the Derwent Glacier to the Rangers Hut area was at least partly a function of the continued shrinkage of the Central Plateau ice cap, which led to a decline in the Mersey Glacier and the ending of diffuent flow from the Mersey Valley through Du Cane Gap. A series of at least a dozen small moraines was constructed between 1160 m and 920 m east of Du Cane Gap as the edge of the Mersey Glacier retreated down the Campfire Creek Valley.

#### (7) Marion Valley moraines

Hummocky moraine occurs in the lower and middle reaches of the Marion Valley upstream of the Rangers Hut Moraines. Nine moraine ridges are present in the upper part of the valley, the innermost of which contains semicircular or irregularly shaped depressions on the ice proximal face. These are interpreted as kettle holes formed during final decay of the ice. The greater development of moraine ridges in the Marion Valley compared to the Hamilton Valley indicates that the Marion Glacier remained more vigorous than the Hamilton Glacier during the final stages of glaciation. It would appear from this that the Guardians formed a far more effective snowfence and provided more adequate shading than did the ridges at the head of the Hamilton Valley.

#### (8) Cephissus Valley moraines

The Cephissus Glacier constructed numerous moraines on rock ribs between the mouth of the Cephissus Valley and the Pine Valley Plains. The innermost of these moraines also exhibits kettle holes. The Cephissus ice flow then ceased, possibly due to the loss of any significant ice input from The Labyrinth. Two intermorainal outwash surfaces are overlain by 2 m of massive gleyed clays deposited by ponded meltwater (Jennings 1959). Intervening hummocky moraine indicates that deposition of the clays occurred in two stages (Derbyshire 1963).

#### (9) Stony Creek moraines

The descent of Stony Creek from the Traveller Range to the Narcissus River is deflected southwards within a series of latero-terminal moraines with crests at 760–780 m. The

Narcissus and Cephissus glaciers were no longer confluent at the time these moraines were constructed.

Retreat of the ice in the Narcissus Valley appears to have been fundamentally different in character from the pattern in the tributary valleys. Fluted drift, in which the crests rise 2–4 m above the swales, is present in the Narcissus Valley, where it has variously been attributed to late glacial meltwater streams (MacLeod *et al.* 1961), to a large glacier moving with vigorous rotational slip (Derbyshire 1963), and to the presence of very thick ice (Peterson 1969). Some apparent flutes can be traced back to small moraines that extend from low divides between hollows that have been scalloped into the main cirque. This is consistent with the proposition that the development of flutes results from a process similar to that involved in the development of crag and tail landforms. This view asserts that flute development is related to the migration of plastic till into cavities in the ice, formed in the lee of obstructions at the glacier sole, where confining ice pressures are low (Galloway 1956, Boulton 1971). At least the largest of the Narcissus flutes have formed in this manner.

Unequivocal fluted drift occurs along c. 4.5 km of the valley floor, from 850 m to 1040 m, and indicates that the ice continued to maintain downvalley flow, even during the final retreat of the glacier terminus. This fluted moraine contrasts with the moraines that exhibit kettle holes and the hummocky moraines which indicate that the ice flow died in the tributary valleys. The fluting originates in the head of the Narcissus Valley and does not extend towards Du Cane Gap. This suggests that the accumulation of ice in the lee of the high Geryon–Acropolis snowfence, rather than continued diffuence through Du Cane Gap, lies behind the comparative longevity of the Narcissus Glacier.

A further small area of fluted drift forms the southern shoreline of a lake several hundred metres northeast of Lake Sappho on the Central Plateau. This fluted drift indicates that at least in this area the plateau ice cap also remained active during its retreat.

### Non-glacial deposits

The nature and distribution of non-glacial deposits assists in determining the extent of the former ice cover, the age relationships between the different phases of glaciation, and the geomorphological evolution of this glacially modified area, subsequent to deglaciation. Diamictic mantle many of the slopes outside the Cynthia Bay ice limits but are scarce within those limits. They reach a depth of 2 m on the upper slopes of the Bedlam Wall ridge. These deposits consist of fragments of local bedrock or clasts up to 2 m or more in size that have been reworked from till, and occur in a silty clay matrix. They have moved over slopes of as little as 8°. These diamictic are interpreted as having been produced by periglacial solifluction.

Slab toppling has produced extensive block slopes beneath many of the free faces. Such deposits are best developed on Mt Olympus but they also occur at Walled Mountain and on the western slopes of Mt Hyperion. They are most extensive beneath re-entrants in the cliff lines. On the northeastern flank of Mt Olympus, large imbricate and joint-bounded blocks can be visually matched with one another. Block accumulations which appear to be the result of slab toppling are moderately common in steep terrain which has been eroded by glaciers.

Toppling is uncommon within the limits of the Bedlam Wall phase and is almost entirely absent within the Cynthia Bay ice limits. However, tongues of very large joint-bounded blocks extend steeply to the valley floor from broad block accumulations high on both sides of the upper Cephissus trough. These blocks are believed to represent topples that collapsed forward as the ice withdrew, together with some talus that was deposited against the ice margin. Another talus that was deposited in contact with the ice occurs at 1260 m on Mt Gould.

Rockfall talus has accumulated in many localities. Mechanically shattered bedrock forms a mantle up to 1 m thick on the northern end of the Bedlam Wall ridge and is probably the result of frost shattering during the Cynthia Bay phase. Processes of rockfall from high dolerite cliffines commonly involve toppling to some extent, but relatively smaller amounts of material are moved in each event, fragments of columns are widely dispersed and the prismatic form of the dolerite blocks is seldom preserved. Accumulations of this kind beneath the cliffs of Mt Olympus lie at a gradient of 20°–30°. There is little freshly broken rock on the surface of the Mt Olympus apron. Rockfall talus and some joint-bounded blocks dominate the lateral moraine north of Lake Helen, but few rockfall deposits are present within the ice limit it defines.

The toppled blocks on the eastern wall of the Cephissus trough are overlapped on the eastern side of the trough by tongues of much smaller calibre rockfall and avalanche talus. Similar deposits also occur beneath the cliffs of Mt Geryon in the Narcissus cirque. A large rockfall deposit on the southwestern slopes of Falling Mountain is associated with abrupt topple-like failure of a glacially over-steepened slope within the limits of the Cynthia Bay phase. The base of the collapse rests upon sediments underlying the dolerite, which suggests that failure of the sediments has brought about cambering (Caine 1982).

### Alluvial, peat and dune deposits

Up to 1.5 m of alluvial silt that contains fragments of charcoal has accumulated as overbank and levee deposits on the Pine Valley plains, and similar sediment forms a small delta where the Narcissus River discharges into the northern end of Lake St Clair. The silts reflect a change from an environment in which vigorous meltwater streams carried mechanically weathered materials from an unstable landscape to an environment in which vegetation was present and the products of predominantly chemical weathering were transported by less vigorous streamflow (Tricart & Cailleux 1972). Organic-rich silt, up to 1.8 m thick, occurs in several rock basins in the Labyrinth, and west of the lakes in the Helen and Enone cirques on Mt Olympus. A core from the smaller of the tarns at 1070 m on the Gould Plateau revealed 85 cm of organic-rich silt overlying minerogenic silt. Fragments of *Athrotaxis selaginoides* at the base of the organic-rich silt indicate that the ice had withdrawn and the landscape had stabilised sufficiently for vegetation to develop prior to its deposition.

Minor paludal deposits have accumulated with fibrous peats on the button-grass plains. Glacial sands have been worked into beaches around parts of the shoreline of Lake St Clair, most notably at the Frankland Beaches at the southern end of the lake. Dunes up to 4 m high have been constructed by aeolian action behind the southern beaches, in response to northwesterly winds down the length of the

lake during the Holocene. This is the largest dune system available for study on a glacial lake in Australia, following inundation of the larger complex at Lake Pedder. Unfortunately, the dune system at Lake St Clair has been subject to unnatural erosion, quarrying and modification of its morphology by construction activities.

### DATING AND DISCUSSION

The differentiation of glacial deposits of different ages is facilitated by their relative positions in the landscape and by the degree of postdepositional modification to which the landforms and sediments have been subject. The use of postdepositional modification, particularly contrasts in clast weathering and in degrees of soil development, as an aid to dating Tasmanian glacial deposits has been reviewed elsewhere (Kiernan 1990b). The glacial deposits of the Lake St Clair area generally occur within previously ice-eroded landforms. They do not define the limits of the ice which was responsible for that erosion. While some summits remained nunataks, including the Acropolis' eastern ridge and Mt Gould, equivocal erosional evidence suggests that, during a very intense early phase of glaciation, the summit of Walled Mountain (1410 m) and many of the summits of the Du Cane Range may have been overridden by ice. The similar width-to-depth ratios of the glaciers and their host cirques suggest that the form of the glaciers was controlled by the cirques (Graf 1976), which emphasises the influence of the pre-existing topography. The surface gradient of the Derwent Glacier near the southern end of the St Clair trough declined eastwards, which suggests that snowfence effects and shading were important influences upon its form. It also suggests that the glaciers which descended into the trough around Mt Ida were of less significance as sources of ice than were the cirques at the head of the Narcissus Valley and its tributaries. Indeed, only a comparatively small part of the Central Plateau ice cap is ever likely to have drained into the Derwent (cf. Derbyshire 1963). Retreat of the Derwent Glacier to the Rangers Hut limit was brought about largely through the decline of the Central Plateau ice cap, which resulted in a halt to the passage of ice from the Mersey Valley into the Derwent via Du Cane Gap.

Weathering rinds formed on subsurface clasts in the Bedlam Wall till vary in thickness from 0.5 to 7.4 mm thick, the mean value and standard deviation being  $2.7 \pm 1.51$  mm. Rinds in the Cynthia Bay till range from 0.1 to 4.6 mm, the mean and standard deviation being  $1.5 \pm 0.46$  mm. While the weathering rinds formed on subsurface dolerite clasts in the Bedlam Wall till are little thicker than those in the Cynthia Bay till, there is a major contrast between the soil profiles that have formed on these two tills. The clay-rich B horizon of the soil, developed primarily by pedogenic weathering of the Bedlam Wall till, is consistently at least three times thicker than in any of the moraines formed subsequently. This indicates that the Bedlam Wall moraines are considerably older than the Cynthia Bay till. During the Bedlam Wall phase of the Beehive Glaciation, the Derwent Glacier extended well south of Lake St Clair. The talus that accumulated in contact with the ice on the northeastern shoulder of Mt Gould at this time indicates that the Cephissus Glacier was at least 400 m thick at this point.

Moraines that abut talus 1 km south of Lake St Clair and in the Lake Helen cirque delineate the maximum extent of

ice during the Cynthia Bay Glaciation. At the peak of the Cynthia Bay Glaciation, the Derwent Glacier extended 27 km from its headwall in the Du Cane Range. Fresh rock crevasses and ice-abraded surfaces on the Gould Plateau indicate that the ice was 300 m thick west of this point. Diffluent ice from the Derwent Glacier passed through two cols northwest of Mt Olympus into the head of the Cuvier Valley until the end of the Peninsula phase. This ice surplus existed partly because the Derwent Glacier was supplemented by the diffluent lobe of the Mersey Glacier, which flowed through Du Cane Gap at the head of the Narcissus Valley, and the discharge of some ice from the western margin of the Central Plateau into the Narcissus Valley.

Postdepositional modification of the landforms and sediments suggests that the glacial deposits as far downstream as the Cynthia Bay moraines do not differ significantly in age. All have very immature soil profiles of A Cox Cu-type (Birkeland 1984), in which a thin A horizon has formed over parent material that has been oxidised but undergone little chemical weathering. The average thickness of dolerite weathering rinds is less than 2 mm. The diamictos that are interpreted as solifluction deposits occur almost exclusively outside the Cynthia Bay ice limits, and the stratigraphically uppermost of them are weathered to a degree comparable to the Cynthia Bay till. This suggests that they are approximately equivalent in age.

Some slab topple deposits occur locally within the Cynthia Bay ice limits. In these cases, toppling appears to have been a response to withdrawal of the supporting ice margin. However, most of the slab topple deposits at the foot of Walled Mountain and at Mt Hyperion lie outside the ice limits of the Cynthia Bay phase, during which time toppled blocks were reworked into moraines on Mt Olympus. This indicates that the main phase of toppling predates the Cynthia Bay phase.

The rockfall deposits at Falling Mountain lie within the ice limits of the Cynthia Bay phase, and in some areas the ground is freshly disturbed. This indicates that the site remains unstable. However, apart from small fragments that have accumulated due to minor rock and snow avalanche activity around Mt Geryon, there is little other evidence of significant rockfall today. Rockfall deposits are scarce within the Cynthia Bay ice limits, although a considerable amount of rockfall material has been reworked into moraines on Mt Olympus. This suggests that the main phase of rockfall activity predates final deglaciation.

Radiocarbon assay of charcoal fragments, obtained from 0.2 m above the base of 1.3 m of deltaic silt that overlies glaciofluvial sediments near the mouth of the Narcissus River, indicates that the climatic amelioration that allowed organic-rich silt to commence accumulating occurred prior to  $7650 \pm 250$  BP (SUA 2079). The fragments of *Athrotaxis selaginoides* at the base of the organic silt in the Gould Plateau tarn have been radiocarbon assayed to  $7920 \pm 250$  BP (SUA 2080). Evidence from elsewhere in the state suggests that actual deglaciation of the highest cirques was complete well prior to this time (Macphail & Peterson 1975), probably by about 9 ka BP.

The degree of postdepositional modification and the morphologic and stratigraphic context of the Cynthia Bay drift bears comparison with that of the Dante drift in the central West Coast Range, which was deposited shortly after  $18\,800 \pm 500$  BP (ANU 2533) (Kiernan 1980, 1983). Similar criteria suggest that these tills are also equivalent in age to the Dixon till in the Franklin Valley (Kiernan 1989),

the Rowallan till in the Mersey Valley (Hannan & Colhoun 1988) and the Oakleigh till in the Forth Valley (Kiernan and Hannan, 1991). Hence, it is with these formations that comparison with the Cynthia Bay drift might best be made, to evaluate the nature of the glacial environment and events during the late Last Glacial Stage.

During the maximum of the Cynthia Bay Glaciation, the Equilibrium Line of the Derwent Glacier lay at c. 1020 m. This implies a depression of the mean annual temperature by c.  $6.2^\circ\text{C}$  compared to its present value. This estimate compares closely with the figure of  $6.5^\circ\text{C}$  calculated by Derbyshire (1973) on the basis of the limits of rock glaciers on the western slopes of Mt Olympus. It is also comparable to the figure proposed by Kiernan (1980) for temperature depression during the Dante Glaciation.

The regular spacing and size of the Cynthia Bay moraines recalls the form of De Geer moraines, which form some distance behind an ice front that calves into water (Stromberg 1965). However, while meltwater may previously have been impounded behind the Bedlam Wall moraine, further downstream a large lake would have been necessary for the Cynthia Bay moraines to have formed in this manner, and there is no evidence for more than localised ponding of meltwater. The development of the Cynthia Bay moraines probably more closely resembles that of Thule-Baffin moraines (Embleton & King 1975), cross-valley landforms that have been described from the wasting margins of cold ice caps in the Thule area of Greenland (Weertman 1961) and on Baffin Island (Andrews & Smithson 1966). The general absence of shear planes in sections exposed along the Cynthia Bay road and Derwent River suggests that the Cynthia Bay moraines are not subglacial forms that have developed in the general manner proposed for Rogen moraines, which involves the shearing of ice over the moraine crest (Goldthwait 1951, Derbyshire 1965, Prest 1968).

Weertman (1961) argued that Thule-Baffin moraines are formed where debris is brought to the ice surface in regelation ice. This is consistent with the limited shearing at Cynthia Bay and is essentially the interpretation favoured by Derbyshire (1965). The Cynthia Bay moraines lack the alluvial fans that commonly form on the distal face of Thule-Baffin moraines (Goldthwait 1951). The reason for this may lie in the thermal regime of the glaciers. Thule-Baffin moraines are formed on the edge of cold ice sheets, where there may be only a limited amount of basal debris entrained. Active temperate ice is likely to entrain more basal debris than will cold ice and, upon reaching the surface, this will form a thicker debris cover and will more effectively insulate the ice, thereby retarding melting and flowage.

The moraine complexes in this area attest to systematic retreat of the glaciers in clear stages, during which abundant proglacial sediments were deposited inside the earlier ice limits. This contrasts with the pattern of retreat during the Last Glaciation interpreted from Tasmania's West Coast Range by Colhoun (1985), who proposed that the large, narrow end moraines in that area were formed by glaciers that were maintained at the maximum glaciation by an approximate balance between accumulation and summer ablation that persisted for a considerable time, after which deglaciation was rapid. The slightly more continental glaciers in the Lake St Clair area may have been more susceptible to minor climatic changes, perhaps particularly in summer ablation conditions, than the very maritime glaciers in the mountains further west. The regular spacing and limited

evidence for shearing suggests that the moraines upstream of the Cynthia Bay terminal moraines are all retreat features. However, insufficient sections are available to confirm this impression. Fitzsimons (1988) has suggested that the Dante Advance in the King Valley may have been preceded by an earlier advance during the Last Glacial Stage, but the evidence for this remains equivocal. The postdepositional data from the Lake St Clair area do not suggest there is any significant age difference between the tills deposited during the Cynthia Bay and Stony Creek phases and do not indicate preservation of evidence for an early Last Glacial Stage advance.

Both erosional and depositional landforms attest to the differences between the glaciers at Lake St Clair and those further west. The shallow and open cirques of the Lake St Clair area contrast with deeper cirques and rock basins in the western mountains, which are the product of higher rates of accumulation and ablation and more vigorous mass throughput. The development of moraines of possible Thule-Baffin type at Lake St Clair reflects the slightly more continental character of glaciation in this area compared to those in the more westerly mountains. These moraines are quite unlike the broader and more massive moraines that were formed further down the Derwent Valley during earlier glaciations (Kiernan 1985, 1991). No moraines of Thule-Baffin type have been recorded in the more maritime areas nearer the west coast. Abundant meltwater in the terminal zones of the glaciers around Lake St Clair is attested to by their composition of up to 75% bedded materials. The evidence from this area suggests limited precipitation, cooler temperatures than in the west, and cryogenesis by congelation (Derbyshire 1963, Peterson 1968, 1969). Nevertheless, the rounded clasts in the basal tills indicate that meltwater was abundant at the glacier sole (Driemanis 1976).

The extensive tract of fluted moraine in the upper Narcissus Valley indicates that the Narcissus Glacier remained active even during its final retreat. In contrast to this, the other tributary valleys contain small end moraines and hummocky drift, which implies that the ice there became inactive and decayed *in situ*. This contrast in late stage glacial deposition indicates that the high Geryon-Acropolis snowfence and the shading from the afternoon sun that it offered were critical factors during the Stony Creek phase.

This analysis of the glacial legacy of the Lake St Clair area therefore indicates that, during the Last Glaciation, the glaciers here were controlled by the topography and played only a comparatively minor role in shaping the landscape, the most striking glacial modification of which occurred during earlier glaciations. Other non-glacial landforms such as slab topples may date at least in part from periglacial episodes during the late Last Glacial Stage but they were facilitated by glacial steepening that occurred earlier. Erosional and depositional evidence indicates that there were slight continental influences on the glacial environment, but that the glaciers were still essentially of temperate type. In apparent contrast to the situation further towards the west coast, however, these inland glaciers retreated systematically in clear stages. The ice flow slowed significantly or stagnated in some smaller valleys, while remaining active in more favourable accumulation sites. No evidence has yet been detected that would suggest any phases of readvance interrupted this steady retreat from the maximum ice limits as the climate ameliorated.

## ACKNOWLEDGEMENTS

The initial phases of this study were undertaken as part of my PhD studies in the Geography Department at the University of Tasmania under the supervision of Dr E. A. Colhoun and with support from the Australian Department of Education under the Commonwealth Postgraduate Research Awards Scheme. For support, advice and assistance during this phase of the study, I am grateful to Dr Les Wood, Dr Michael Macphail, Mick Iloski and Karen Kiernan. For assistance in various ways during both this and later phases of the study, I also wish to thank the Department of Parks, Wildlife and Heritage, particularly Dick Dwyer and Steve Hepworth, and Dr Mick Brown of the Forestry Commission.

## REFERENCES

- ANDREWS, J.T. & SMITHSON, B.B., 1966: Till fabrics of the cross valley moraines of north-central Baffin Island, NWT, Canada. *Bull. Geol. Soc. Am.* 77: 271-290.
- BANKS, M.R., 1973: General geology. In Banks, M.R. (Ed.) *THE LAKE COUNTRY OF TASMANIA*. Royal Society of Tasmania, Hobart: 25-34.
- BANKS, M.R., 1981: The rocks of Mt Wellington. *THE ORGAN PIPES, MT WELLINGTON*. Climbers Club of Tasmania: 20-23.
- BIRKELAND, P.W., 1984: *SOILS AND GEOMORPHOLOGY*. Oxford University Press, New York: 372pp.
- BLATT, H., MIDDLETON, G. & MURRAY, R., 1972: *ORIGIN OF SEDIMENTARY ROCKS*. Prentice Hall, New Jersey: 643pp.
- BOULTON, G.S., 1971: Till genesis and fabric in Svalbard, Spitsbergen. In Goldthwait, R.P. (Ed.) *TILL, A SYMPOSIUM*. Ohio State University Press: 41-72.
- CAINE, N., 1982: Toppling failures from alpine cliffs on Ben Lomond, Tasmania. *Earth Surf. Proc. Landf.* 7: 133-152.
- CLEMES, W.H., 1925: Notes on a geological reconnaissance of the Lake St Clair district. *Pap. Proc. R. Soc. Tasm.* (1924): 59-72.
- COLHOUN, E.A., 1985: Glaciations of the West Coast Range, Tasmania. *Quat. Res.* 24: 39-59.
- DAVIES, J.L., 1959: High level erosion surfaces and landscape development in Tasmania. *Austr. Geogr.* 7: 193-203.
- DAVIES, J.L., 1969: *LANDFORMS OF COLD CLIMATES*. ANU Press, Canberra. 200pp.
- DERBYSHIRE, E., 1963: Glaciation of the Lake St Clair district, west-central Tasmania. *Austr. Geogr.* 9: 97-110.
- DERBYSHIRE, E., 1964: Australian landform example no.2: cirques. *Aust. Geogr.* 9: 178-179.
- DERBYSHIRE, E., 1965: The internal constitution of a Tasmanian end moraine. *J. Geol.* 73: 377-383.
- DERBYSHIRE, E., 1967: Glacial geomorphology and climate of the mountains of western Tasmania, with special reference to the north-west centre. Unpubl. PhD thesis, Department of Geography, Monash University.
- DERBYSHIRE, E., 1968a: Cirque. In Fairbridge, R.W. (Ed.): *ENCYCLOPEDIA OF GEOMORPHOLOGY*. Rienhold, New York: 119-125.
- DERBYSHIRE, E., 1968b: Glacial Map of NW-central Tasmania. *Rec. Geol. Surv. Tasm.* 6, Tasm. Dep. Mines., Hobart.
- DERBYSHIRE, E., 1971: A bathymetric survey of Lake St Clair. *Pap. Proc. R. Soc. Tasm.* 105: 49-57.
- DERBYSHIRE, E., 1972: Pleistocene glaciation of Tasmania: Review and speculations. *Austr. Geogr. Stud.* 10: 79-84.
- DERBYSHIRE, E., 1973: Periglacial phenomena in Tasmania. *Buil. Peryglac.* 22: 131-148.
- DERBYSHIRE, E., BANKS, M.R., DAVIES, J.L. & JENNINGS, J.N., 1965: *A GLACIAL MAP OF TASMANIA*. *R. Soc. Tasm. Spec. Publ.* 2.

- DRIEMANIS, A., 1976: Tills: Their origin and properties. In Leggett, R.F. (Ed.): *GLACIAL TILL*. Royal Society of Canada, Ottawa: 11–49.
- EMBLETON, C. & KING, C.A.M., 1975: *GLACIAL GEOMORPHOLOGY*. Arnold, London: 583pp.
- ENGLAND, J., BRADLEY, R.S. & STUCKENRATH, R., 1981: Multiple glaciations and marine transgressions, western Kennedy Channel, Northwest Territories, Canada. *Boreas* 10: 71–89.
- FAIRBRIDGE, R.W., 1968: Quaternary period. In Fairbridge, R. W. (Ed.): *ENCYCLOPEDIA OF GEOMORPHOLOGY*. Rienhold, New York: 912–931.
- FITZSIMONS, S.J., 1988: The Quaternary stratigraphy and sedimentology of the King River Valley, Western Tasmania. Unpubl. PhD thesis, University of Tasmania: 276 pp.
- GALLOWAY, R.W., 1956: The structure of moraines in Lyngdalen, north Norway. *J. Glaciol.* 2(2): 730–733.
- GOLDTHWAIT, R.P., 1951: Development of end moraines in east-central Baffin Island. *J. Geol.* 59: 566–576.
- GOULD, C., 1860: Exploration of the western country. *Tasm. House of Assem. J.* 4(4): 4–9.
- GRAF, W.L., 1976: Cirques as glacier locations. *Arct. Alp. Res.* 8(1): 79–86.
- HALE, G.E., 1958: Some aspects of jointing and decomposition in Tasmanian dolerites. In Carey, S.W. (Ed.): *DOLERITE—A SYMPOSIUM*. Department of Geology, University of Tasmania: 184–196.
- HANNAN, D.G. & COLHOUN, E.A., 1988: The glacial stratigraphy of the upper Mersey Valley. *Austr. Geog. Stud.* 25(2): 36–46.
- HATCH, F.H., RASTAL, R.H. & GREENSMITH, J.T., 1971: *PETROLOGY OF THE SEDIMENTARY ROCKS*. Murby, London: 502pp.
- JENNINGS, I.B., 1959: Geology of the Cradle Mountain Reserve. *Tech. Rep. Dep. Mines Tasm.* 3: 73–78.
- JENNINGS, J.N. & AHMAD, N., 1957: The legacy of an ice cap. *Austr. Geog.* 7: 62–75.
- KIERNAN, K., 1980: Pleistocene Glaciation of the Central West Coast Range, Tasmania. Unpubl. BSc Hons thesis, Department of Geography, University of Tasmania: 247 pp.
- KIERNAN, K., 1983: Weathering evidence for an additional glacial stage in Tasmania. *Austr. Geog. Stud.* 21(2): 197–220.
- KIERNAN, K., 1985: Late Cainozoic glaciation and mountain geomorphology in the Central Highlands of Tasmania. Unpubl. PhD thesis, Department of Geography, University of Tasmania: 2 vols, 557 pp.
- KIERNAN, K., 1989: Multiple glaciation of the upper Franklin Valley, Western Tasmania Wilderness World Heritage Area. *Austr. Geog. Stud.* 27: 208–233.
- KIERNAN, K., 1990a: The extent of late Cainozoic glaciation in the Central Highlands of Tasmania. *Arct. Alp. Res.* 22(4): 341–354.
- KIERNAN, K., 1990b: Postdepositional modification as an aid to dating Tasmanian glacial deposits. *Austr. Geogr.* 21: 1–17.
- KIERNAN, K., 1991: Glacial history of the upper Derwent Valley, Tasmania. *NZ J. Geol. Geophys.* 34(2): 157–166.
- KIERNAN, K. & HANNAN, D., 1991: Glaciation of the upper Forth River catchment, Tasmania. *Austr. Geog. Stud.* 29 (1): 155–173.
- LEWIS, A.N., 1939: Notes on Pleistocene glaciation, Mt Field to Strahan. *Pap. Proc. R. Soc. Tasm.* (1938): 161–173.
- LEWIS, A.N., 1945: Pleistocene glaciation in Tasmania. *Pap. Proc. R. Soc. Tasm.* (1944): 41–56.
- MACLEOD, W.N., JACK, R.H. & THREADER, V.N., 1961: *Du Cane, Tasmania*. Tasm. Dep. Mines 1 Mile Geol. Atlas Ser., Explan. Rep., Sheet K55–11–52.
- MACPHAIL, M.K. & PETERSON, J.A., 1975: New deglaciation dates from Tasmania. *Search* 6(4): 127–130.
- OFFICER, G., BALFOUR, L. & HOGG, E.G., 1895: Geological notes on the country between Strahan and Lake St Clair. *Proc. R. Soc. Vict.* 7 (n.s.): 119–130.
- PETERSON, J.A., 1968: Cirque morphology and Pleistocene ice formation conditions in southeastern Australia. *Austr. Geog. Stud.* 6: 67.
- PETERSON, J.A., 1969: The cirques of southeastern Australia: Studies in morphology and distribution; history and significance. Unpubl. PhD thesis, Monash University, Melbourne: 2 vols, 417 pp.
- PETERSON, J.A. & ROBINSON, G., 1969: Trend surface mapping of cirque floor levels. *Nature* 222: 75.
- PREST, V.K., 1968: Nomenclature of moraines and ice-flow features as applied to the glacial map of Canada. *Geol. Surv. Pap. Can.* 67-57: 32 pp.
- SPRY, A.H. & HALE, G.E., 1964: A cave in dolerite at Wayatinah, Tasmania. *J. Geol. Soc. Aust.* 11(2): 213–216.
- STROMBERG, B., 1965: Mapping and geochronological investigations in some moraine areas of south-central Sweden. *Geogr. Ann.* 47A: 73–82.
- TRICART, J. & CAILLEUX, A., 1972: *INTRODUCTION TO CLIMATIC GEOMORPHOLOGY*. Longman, London: 295pp.
- WEERTMAN, J., 1961: Mechanism for the formation of inner moraines found near the edges of cold icecaps and ice sheets. *J. Glaciol.* 3: 965–978.

(accepted 14 February 1992)



## EARLY IDAMEAN (LATE CAMBRIAN) AGNOSTOID TRILOBITES FROM THE HUSKISSON RIVER, TASMANIA

by J.B. Jago and A V. Brown

(with one text-figure and two plates)

JAGO, J.B. & BROWN, A.V., 1992 (31:x): Early Idamean (Late Cambrian) agnostoid trilobites from the Huskisson River, Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 59–65. ISSN 0080–4703. Department of Applied Geology, Gartrell School of Mining, Metallurgy and Applied Geology, University of South Australia, The Levels, SA, Australia 5095 (JB); and Geological Survey of Tasmania, Department of Mines, PO Box 56, Rosny Park, Tasmania, Australia 7018 (AVB).

Two trilobite taxa, *Agnostus* (*Homagnostus*) sp. and *Pseudagnostus* (*Pseudagnostus*) *idalis huskissonensis* subsp. nov. are described from the upper part of the Huskisson Group, western Tasmania. The only trilobite previously described from this level is the early Idamean (early Late Cambrian) zone fossil *Glyptagnostus reticulatus*. Palaeontological and stratigraphic evidence suggests that there may be a disconformity of very late Middle Cambrian age (about *Lejopyge laevigata* III Zone) within the Huskisson Group, which would correspond to a postulated disconformity of similar age from the Dundas Group at Dundas.

**Key Words:** trilobite, agnostoid, Cambrian, Tasmania.

### INTRODUCTION

The early Late Cambrian zone fossil *Glyptagnostus reticulatus* (Angelin) has been known from the Huskisson River area of western Tasmania for some years (Öpik 1951, Banks 1956, 1962, Blissett 1962, Jago 1974). The purpose of this paper is to describe some additional trilobite species recently found in association with *G. reticulatus* and to discuss briefly their stratigraphic significance. AVB is responsible for the stratigraphic part of this paper; JBJ is responsible for the palaeontology.

### STRATIGRAPHIC SETTING

Four new locations of the *Glyptagnostus reticulatus* fauna were found during re-mapping of the type area of the Huskisson Group for the *Corinna* 1:50 000 Geological Atlas Map Sheet (Turner *et al.* 1991), before it was inundated by flooding to form Lake Pieman. The positions of three of these localities are shown in figure 1. The Huskisson Group was defined by Taylor (1954) who divided the group into nineteen unnamed formations. The majority of the sequence consists of volcanoclastic conglomerate beds and lenses within a laminated siltstone and mudstone sequence. Although the Huskisson Group is, in part, a biostratigraphic correlate of the Dundas Group, the dominance in most of the Huskisson Group sequence of acid to intermediate volcanic detritus indicates a different provenance from that of the Dundas Group in its type area (Brown 1986).

In general, the Huskisson Group can be divided into three parts. An upper and lower sequence dominated by conglomerate units and an intervening succession of laminated mudstone and siltstone.

The lower conglomerate dominated sequence (Units 1–13 of Taylor) is approximately 950 m thick and derived from a mixed metasedimentary and active acid to intermediate volcanic terrain (Chv & Chm, fig. 1). The upper conglomeratic sequence (Units 15–17 and 19 of Taylor, Chm, fig. 1), of which only 200 m of section survive in the type area, was derived from a dominantly metasedimentary source, with minor, reworked, volcanic

material. Between the two conglomeratic sequences occurs an approximately 45 m interval of richly fossiliferous black pyritic mudstone and siltstone with minor sandstone beds (Unit 14 of Taylor, Chm, fig. 1). The fossils described herein come from this unit. Detailed descriptions of these sequences can be found in Brown (1986).

In the Merton Hill area, to the northwest of the area under discussion, two new fossil locations were also found within the volcanoclastic part of the succession (Brown 1986). These faunas are of late Middle Cambrian age and, as only 50 m of section separates these horizons from the *Glyptagnostus reticulatus* faunas, a disconformity around the *Lejopyge laevigata* III Zone is suggested. On this data, the lower conglomerate sequence would correlate with the mid to late Middle Cambrian volcanic phase, which is also recorded in the Que River area, and would be, in part, a biostratigraphic correlate of the Razorback Conglomerate of the Dundas Group and be part of the lower Dundas Group of Brown (1986). On the fossil data from the original and new locations in the Huskisson River, the upper conglomerate and fossiliferous mudstone would be correlates of the Fernflow–Comet–Fernfield–Climie Formations of the Dundas Group and belong to the upper Dundas Group of Brown (1986).

As the faunas in the volcanoclastic part of the succession are of late Middle Cambrian age and only 50 m of section separate these horizons from the upper siliceous conglomerate–mudstone sequence with the *Glyptagnostus reticulatus* horizon in the lower part, the possibility of a disconformity during the *Lejopyge laevigata* III Zone, as suggested by Brown (1986) from evidence in the type area of the Dundas Group at Dundas, is further supported.

In addition to a resampling of the original location (just southeast of locality 1143 on fig. 1) from Unit 18 of Taylor (1954), three new localities (including 1143 and 1197) were found upstream from Taylor's original location but still within Unit 18. Locality 1079 contains abundant *Glyptagnostus reticulatus* and sponge spicules (Clarke 1986). The faunas from locality 1143, as described herein, contain abundant *Agnostus* (*Homagnostus*) sp., and *Pseudagnostus* (*Pseudagnostus*) *idalis huskissonensis* subsp. nov., plus rare *G. reticulatus* as well as sponge spicules. Prior to these

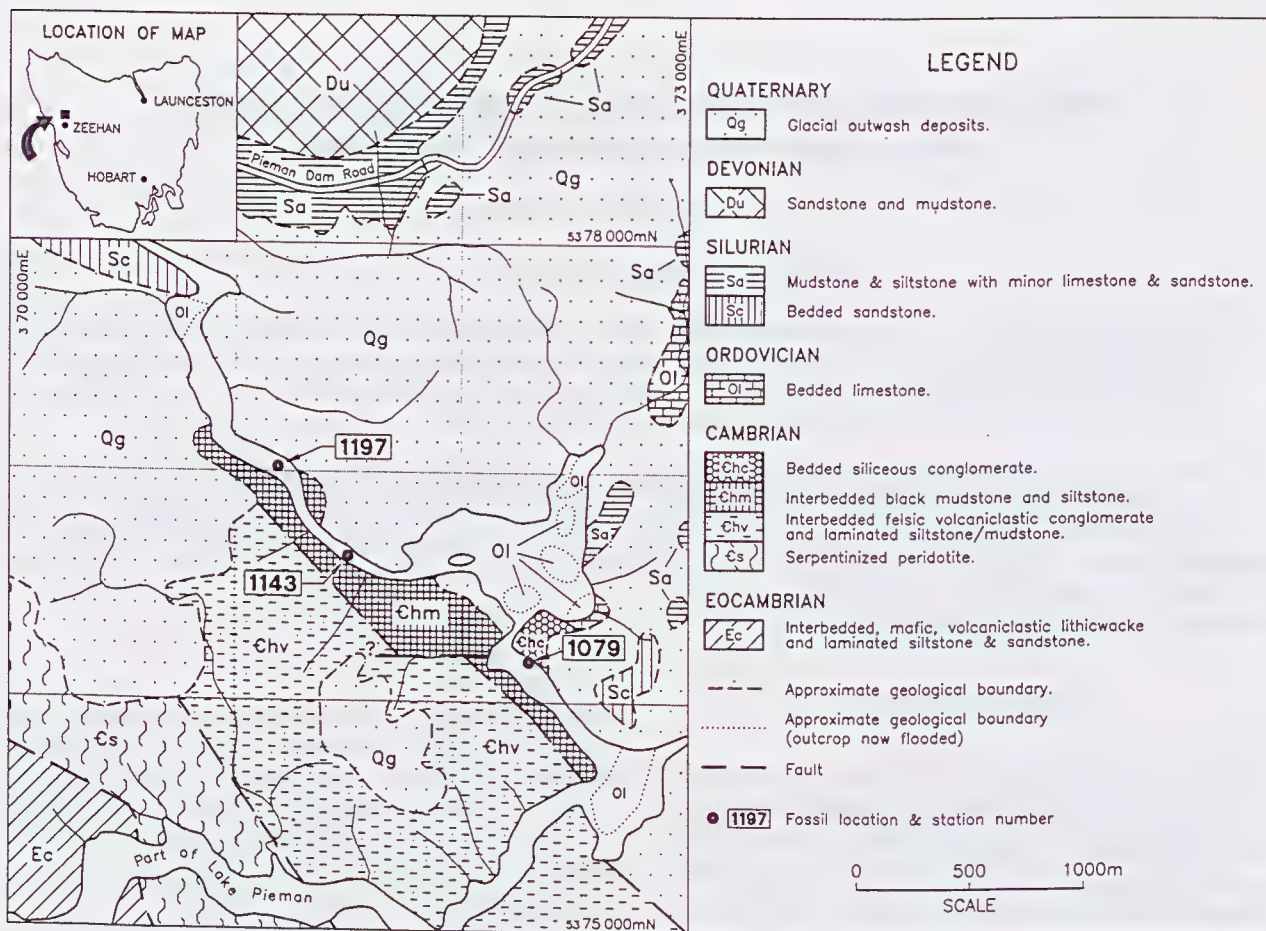


FIG. 1 — Schematic geological map with fossil locations of the Huskisson River area, western Tasmania. Modified after figure 1 of Brown (1986). All fossils described herein come from locality 1143.

discoveries, the only known trilobite from the Huskisson River faunas was *G. reticulatus* Jago (1974).

The fourth new locality (1079 on fig. 1) is from within Unit 14 of Taylor, but upstream of his fossil locality, and contains abundant *G. reticulatus* and spicules of *Protospongia* sp., as well as fragments of other small agnostoids. The occurrence of this fauna substantiates the suggestion of Blissett (1962) that Unit 14 and Unit 18 of Taylor (1954) represent the same stratigraphic unit.

### AGE OF FAUNA

The presence of the important zone fossil *Glyptagnostus reticulatus* indicates an early Idamean age. In Queensland, *G. reticulatus* is found in the basal Idamean *G. reticulatus* Assemblage Zone and in the passage from the *G. reticulatus* Zone up into the *Proceratopyge cryptica* Assemblage Zone (Shergold 1982: 11). In Queensland *Pseudagnostus idalis* and its subspecies range throughout the Idamean (Öpik 1967, Shergold 1982). A subspecies of *P. idalis* is also found in the Idamean Singing Creek Formation of southwestern Tasmania (Jago 1987). *Homagnostus* as defined by Shergold *et al.* (1990: 33) has an Idamean to immediately post-Idamean age. In view of the presence of *G. reticulatus*, the most likely age of the Huskisson River fauna is the *G. reticulatus* Zone on the Australian biochronological scale.

### TREATMENT

All specimens from the Huskisson River locality are preserved as internal or external moulds in grey or black siltstone. For description, latex casts of the external moulds were prepared; either the latex casts or the internal moulds were then photographed after whitening with magnesium oxide. All specimens are housed in the collection of the Geological Survey of Tasmania (GST).

### SYSTEMATIC DESCRIPTIONS

Family AGNOSTIDAE M'Coy, 1849  
Subfamily AGNOSTINAE M'Coy, 1849  
Genus *Agnostus* Brongniart, 1822  
Subgenus *Homagnostus* Howell, 1935

#### Type species

*Agnostus pisiformis* Linnaeus var. *obesus* Belt (1867: 295, pl. 12, fig. 4a–d).

#### Discussion

Shergold (1982), in discussing *Homagnostus* Howell, 1935, treated it as a separate genus. He placed *Oncagnostus* Whitehouse, 1936 and *Proagnostus* Butts, 1926 in synonymy with *Homagnostus*. As noted by Shergold (1982), one of the problems in dealing with the classification of *Homagnostus*

has been the poorly known type material. Rushton (in Allen *et al.* 1981) selected a lectotype of *Homagnostus obesus* and has since discussed and figured the species in more detail (Rushton 1983).

Shergold *et al.* (1990: 5) revised the classification of the Agnostinae and considered *Homagnostus* should be "reinstated as a subgenus of *Agnostus*, representing morphs with a laterally expanded and extended pygidial axis". This essentially reverted to the work of Westergård (1947: 4), who first suggested that *Homagnostus* should be considered as a subgenus of *Agnostus*. The concept of Shergold *et al.* (1990) is followed herein.

Robison (1988: 41) revived the concept of *Proagnostus* as a separate genus. Shergold *et al.* (1990: 5) considered that *Oncagnostus* should be regarded as a separate genus with three subgenera, viz. *O.* (*Oncagnostus*), *O.* (*Kumagnostus*) and *O.* (*Strictagnostus*).

#### *Agnostus (Homagnostus) sp.* (pl. 1A–S)

##### Material

One complete specimen plus numerous, generally poorly preserved individual cephalae and pygidia are available.

##### Description

Small cephalon about as wide as long. Narrow border; shallow, deliquiate border furrow. Deep axial furrows; well-developed preglabellar median furrow. Length of glabella 0.65–0.75 that of cephalon. Shallow, transverse glabellar furrow. Glabellar anterior sharply rounded to pointed. Broadly rounded glabellar posterior. Glabellar node centrally placed on posteroglabella. Small, simple basal lobes. Acrolobes appear unconstricted, although manner of preservation makes assessment difficult.

Pygidium slightly wider than long. Moderately wide border. Deliquiate border furrow. Unconstricted acrolobes. Well-developed posterolateral spines placed just forwards of acrolobe posterior. Wide pygidial axis has length 0.7–0.8 that of pygidium. Narrow, well-developed axial furrows.  $F_1$  and  $F_2$  lateral axial furrows shallow but well developed. Axis narrows at  $M_2$ ; slightly to well-expanded posteroaxis with broadly rounded posterior. Elongated node extends from  $M_2$  on to anterior part of posteroaxis.

##### Morphogenesis

The major changes during growth are shown on the pygidium, where the pygidial axis becomes relatively wider in larger specimens and there is an expansion of the posteroaxis (pl. 1K–S). A similar change was reported and illustrated for *Homagnostus obesus* by Rushton (1983).

##### Discussion

The small agnostoids belonging to *Homagnostus* from this fauna are placed tentatively into a single species. It could be argued that two species could be distinguished, with specimens such as GST15032 (pl. 1L) and GST15027 (pl. 1S), which have an expanded pygidial posteroaxis, being placed in a second species. However, for the most part it is the larger specimens which have an expanded posteroaxis and it is considered that this expansion is due to these specimens being the end members of the morphogenetic range rather than representing a second species. The two pygidia of *Homagnostus alaskensis* Palmer (1968: pl. 7, figs 9, 14) show

a similar change, with the larger pygidium having a more expanded posteroaxis than the smaller.

*Homagnostus captiosus* figured in Lazarenko (1966: pl. 1, figs 13–23) also shows variation in the shape of the posteroaxis. However, with *captiosus* there is no regular increase in expansion of the posteroaxis as there is with *Homagnostus obesus*, and the Tasmanian form, although the smallest pygidium of *captiosus* figured by Lazarenko (1966: pl. 1, fig. 22), has the most parallel-sided pygidial axis of the pygidia figured by Lazarenko.

The Tasmanian species has some similarities to *Homagnostus obesus* (Belt) as figured in Rushton (1983), although the pygidial axis extends further to the posterior than in most of the Tasmanian specimens. In the larger Tasmanian pygidia, the posteroaxis is more expanded than in *obesus*. The posterolateral spines of *obesus* are placed further forward than in the Tasmanian species.

The species described by Shergold (1982) as *Homagnostus sp.1* and *H. sp.2* also show similarities to the Tasmanian species. The pygidial axis of *H. sp.1* is more parallel-sided and extends further to the posterior than those of the Tasmanian form. *Homagnostus sp.2* of Shergold has an expanded posteroaxis, as in the larger Tasmanian specimens, although the pygidial axis of *H. sp.2* also extends further to the posterior. The posterolateral spines of the Huskisson River specimens are larger than those in the single pygidium of *H. sp.2* as illustrated by Shergold (1982: pl. 5, fig. 12).

#### Subfamily GLYPTAGNOSTINAE

Whitehouse, 1936

Genus *Glyptagnostus* Whitehouse, 1936

##### Type Species

*Glyptagnostus toreuma* Whitehouse (1936: 101–103, pl. 9, figs 17–20) (= *Agnostus reticulatus* Angelin, 1851: 8).

*Glyptagnostus reticulatus reticulatus* (Angelin, 1851)  
(pl. 1T)

##### Remarks

One poorly preserved partial pygidium, GST15000a+b, of this cosmopolitan zone fossil is available. The preservation is such that no formal description or discussion is warranted. This taxon has been described and figured previously from the Huskisson River area by Jago (1974).

#### Family DIPLAGNOSTIDAE Whitehouse, 1936

Subfamily PSEUDAGNOSTINAE

Whitehouse, 1936

Genus *Pseudagnostus* Jaekel, 1909

Subgenus *Pseudagnostus* Jaekel, 1909

##### Type Species

*Agnostus cyclopyge* Tullberg, 1880: 26, pl. 2, fig. 15a,c.



## PLATE 1

(A–S) *Aagnostus (Homagnostus) sp.* (A) GST15003, almost complete specimen, internal mould,  $\times 15$ . (B) GST15023, cephalon, external mould,  $\times 15$ . (C) GST15026, cephalon, internal mould,  $\times 15$ . (D) GST15025, cephalon, internal mould,  $\times 10$ . (E) GST15004, cephalon, internal mould,  $\times 20$ . (F) GST15005, cephalon, internal mould,  $\times 15$ . (G) GST15006, cephalon, internal mould,  $\times 15$ . (H) GST15029, cephalon, external mould,  $\times 10$ . (I) GST15021, cephalon, internal mould,  $\times 14$ . (J) GST15007, pygidium, internal mould,  $\times 15$ . (K) GST15008, pygidium, external mould,  $\times 15$ . (L) GST15032, pygidium, internal mould,  $\times 15$ . (M) GST15010, pygidium, external mould,  $\times 15$ . (N) GST15011, pygidium, internal mould,  $\times 20$ . (O) GST15009, pygidium, external mould,  $\times 20$ . (P) GST15012, pygidium, internal mould,  $\times 20$ . (Q) GST15013, pygidium, external mould,  $\times 15$ . (R) GST15028, pygidium, external mould,  $\times 10$ . (S) GST15027, pygidium, external mould,  $\times 15$ . (T) *Glyptagnostus reticulatus reticulatus*. GST15000b, pygidium, internal mould,  $\times 10$ . (U–W) *Pseudagnostus (Pseudagnostus) idalis huskissonensis subsp. nov.* (U) GST15018, complete specimen, external mould,  $\times 8$ . (V) GST15022, complete specimen, internal mould,  $\times 8$ . (W) GST15001b, complete specimen, internal mould,  $\times 8$ . All specimens were whitened with magnesium oxide prior to photography.

*Pseudagnostus (Pseudagnostus) idalis* Öpik, 1967  
*Pseudagnostus (Pseudagnostus) idalis huskissonensis*  
 subsp. nov.  
 (pl. 1U–W, pl. 2A–O)

#### Diagnosis

A subspecies of *P. (P.) idalis* with a relatively long anteroglabella, an anteriorly placed glabellar node, a pygidium with well-developed accessory furrows and short posterolateral spines placed well forward of the deuterolobe posterior.

#### Holotype

The almost complete specimen, GST15024 (pl. 2A), is designated as holotype.

#### Material

About ten complete specimens plus about twenty individual cephalons and twenty individual pygidia. The individual cephalons and pygidia include some immature specimens.

#### Description

Cephalon slightly wider than long. Narrow, slightly convex border; very wide, shallow border furrow. Constricted acrolobe length c. 0.9 that of cephalon. Well-defined preglabellar median furrow. Genae appear to be smooth, although a slight scrobiculation would not be distinguished from the effects of distortion. Parallel-sided glabella has a length c. 0.65–0.7 that of cephalon; at transverse glabellar furrow, glabella width c. 0.25–0.3 that of cephalon. Glabella bounded by moderately deep axial furrows. Simple basal lobes linked by narrow connective band. Shallow transverse glabellar furrow curves gently rearwards. In some specimens (e.g. pl. 2B) there is a suggestion of an  $F_2$  furrow with the glabella being very slightly expanded between  $F_2$  and the transverse glabellar furrow. Elongated glabellar node placed well forward at approximate position of  $F_2$  furrows.

Pygidium wider than long. Narrow, convex border; very wide, shallow border furrow. Narrow, elevated, strongly geniculate shoulders. Wide, shallow articulating furrow arched posteriorly; short (sag.), elevated articulating half-ring. Markedly constricted acrolobe has a length c. 0.8–0.9 that of pygidium (excluding axial half-ring).

Anteroaxis outlined by shallow axial furrows which converge very gently to  $F_2$  furrow.  $M_2$  slightly longer (sag.) than  $M_1$ . Prominent, elongated node on  $M_2$  extends across  $F_2$  and on to posteroaxis.  $F_1$  furrow very shallow;  $F_2$  furrow shallow and directed inwards and very slightly to posterior from either end.

Shallow but well-defined accessory furrows; if continued across border, they would strike pygidial margin a little to posterior of posterolateral spines. Short posterolateral spines placed well forward of deuterolobe posterior. Smooth pleural areas.

The cracked nature of many of the specimens, both cephalons and pygidia, suggests that the subspecies had a thin shell.

#### Morphogenesis

In immature cephalons, such as that shown in plate 2K, the border furrow is narrower than in the more mature specimens. In immature pygidia (pl. 2M–O), the border is also narrower than in more mature specimens. The deuterolobe becomes progressively relatively larger in more mature specimens. A similar increase in deuterolobe size with growth is seen in

*Pseudagnostus vastulus*, as illustrated by Shergold (1982: pl. 1, figs 8–14). As in *vastulus*, the posterolateral spines of *huskissonensis* migrate forwards with growth.

#### Discussion

*Pseudagnostus idalis huskissonensis* is placed within the *P. idalis* complex, as discussed by Shergold (1982). It is somewhat difficult to compare the Huskisson River specimens with the various species of *Pseudagnostus* described by Öpik (1967), Henderson (1976) and Shergold (1982) from Queensland, because the Queensland specimens are preserved in limestone and retain their convexity, whereas the Huskisson River specimens are flattened and occur in shale. Nevertheless, there appear to be enough differences to justify the erection of a new subspecies. The anteroglabella of *huskissonensis* is larger than those of *P. idalis idalis* or *P. i. sagittus* from Queensland or that of *P. i. denisonensis* from southwestern Tasmania. However, the anteroglabella of *huskissonensis* is of similar size to that figured in Shergold (1982: pl. 2, fig. 14) as *P. idalis* Öpik, 1967, *sensu lato*, and indeed the glabella of *P. i. huskissonensis* is indistinguishable from *P. idalis sensu lato*. However, the pygidium of *P. idalis sensu lato* figured by Shergold (1982: pl. 2, fig. 15) is much more effaced than that of *huskissonensis*. The glabellar node of *huskissonensis* is placed further forwards than that of *denisonensis*, but is in a similar position to that of *P. i. idalis* and *P. i. sagittus*. The cephalic border of *huskissonensis* is narrower than that of *denisonensis*. The pygidial spines of *P. i. huskissonensis* are placed further forwards than those of the other subspecies of *P. idalis*.

#### *Pseudagnostus* sp. (pl. 2P)

#### Remarks

One large cephalon (GST15030), in which the axial furrows fade out to the anterior and in which there is no clearly defined transverse glabellar furrow or preglabellar median furrow, may be an aberrant specimen of *Pseudagnostus idalis huskissonensis*. However, due to the differences noted above, it is referred to *Pseudagnostus* sp.

## ACKNOWLEDGEMENTS

The cataloguing and forwarding of these specimens was arranged by M.J. Clarke (Geological Survey of Tasmania). This work was supported by an ARC grant to JBJ.

## REFERENCES

- ALLEN, P.M., JACKSON, A.A. & RUSHTON, A.W.A., 1981: The stratigraphy of the Mawddach Group in the Cambrian succession of North Wales. *Proc. Yorkshire Geol. Soc.* 43: 295–329.
- ANGELIN, N.P., 1851: *Palaeontologica Suecica. Pars. 1. Iconographica crustaceorum formationis transitionis. Fasc. 1:* 1–24.
- BANKS, M.R., 1956: The Middle and Upper Cambrian Series (Dundas Group and its correlates) in Tasmania. In *El Sistema Cambrico, su Paleogeografía y el Problema de su Base*. 20th Session of the International Geological Congress, Mexico, 2: 165–212.
- BANKS, M.R., 1962: The Cambrian System. *J. Geol. Soc. Aust.* 9: 127–145.
- BELT, T., 1867: On some new trilobites from the upper Cambrian rocks of North Wales. *Geol. Mag.* 4: 294–295.



## PLATE 2

(A–O) *Pseudagnostus* (*Pseudagnostus*) *idalis huskissonensis* subsp. nov. (A) GST15024, holotype, complete specimen, internal mould,  $\times 8$ . (B) GST15014, cephalon, internal mould,  $\times 8$ . (C) GST15020, cephalon, internal mould,  $\times 8$ . (D) GST15015, cephalon, external mould,  $\times 8$ . (E) GST15019, pygidium, internal mould,  $\times 8$ . (F) GST15033, cephalon, internal mould,  $\times 8$ . (G) GST15017, pygidium, external mould,  $\times 8$ . (H) GST15034, pygidium, internal mould,  $\times 8$ . (I) GST15031, pygidium, internal mould,  $\times 8$ . (J) GST15035, cephalon, internal mould,  $\times 10$ . (K) GST15037, cephalon, internal mould,  $\times 15$ . (L) GST15038, cephalon, internal mould,  $\times 10$ . (M) GST15039, pygidium, internal mould,  $\times 15$ . (N) GST15036, pygidium, internal mould,  $\times 15$ . (O) GST15016, pygidium, external mould,  $\times 10$ .

(P) *Pseudagnostus* sp. GST15030, cephalon, external mould,  $\times 8$ .

All specimens were whitened with magnesium oxide prior to photography.

- BLISSETT, A.H., 1962: *Zeehan, Tasmania*. Tasm. Dep. Mines 1 mile Geol. Atlas Ser. Explan. Rep., Sheet 50 (7914S).
- BROWN, A.V., 1986: Geology of the Dundas–Mt. Lindsay–Mt. Ramsay area. *Geol. Surv. Tasm. Bull.* 62.
- CLARKE, M.J., 1986: Late Cambrian agnostid faunas from the Huskisson River area. *Geol. Surv. Tasm. Bull.* 62: appendix 1, 151.
- HENDERSON, R.A., 1976: Upper Cambrian (Idamean) trilobites from western Queensland, Australia. *Palaeontology* 19: 325–364.
- JAGO, J.B., 1974: *Glyptagnostus reticulatus* from the Huskisson River, Tasmania. *Pap. Proc. R. Soc. Tasm.* 107: 117–127.
- JAGO, J.B., 1987: Idamean (Late Cambrian) trilobites from the Denison Range, south-west Tasmania. *Palaeontology* 30: 207–231.
- LAZARENKO, N.P., 1966: Biostratigraphy and some new trilobites from the Upper Cambrian of the Olenek Uplift and Karaulakh Mountains. *Uchenye Zapiski, Paleontologiya i Biostratigrafiya* 11: 33–78. [In Russian.]
- ÖPIK, A.A., 1951: Discovery of fossiliferous Upper Cambrian in Tasmania. *Bur. Miner. Resour., Geol. Geophys. Aust. Rec.* 195: 1–40.
- ÖPIK, A.A., 1967: The Mindyallan fauna of north-western Queensland. *Bur. Miner. Resour., Geol. Geophys. Aust. Bull.* 74(1): 404 pp; 74(2): 167 pp.
- PALMER, A.R., 1968: Cambrian trilobites of East-Central Alaska. *US Geol. Surv. Prof. Pap.* 559-B: 1–105.
- ROBISON, R.A., 1988: Trilobites of the Holm Dal Formation (late Middle Cambrian), central North Greenland. *Meddelelser om Grønland. Geoscience* 20: 23–103.
- RUSHTON, A.W.A., 1983: Trilobites from the Upper Cambrian *Olenus* Zone in central England. *Spec. Pap. Palaeontol.* 30: 107–139.
- SHERGOLD, J.H., 1982: Idamean (Late Cambrian) trilobites, Burke River Structural Belt, Western Queensland. *Bur. Miner. Resour., Geol. Geophys. Aust. Bull.* 187: 1–70.
- SHERGOLD, J.H., LAURIE, J.R. & SUN, X.-W., 1990: Classification and review of the trilobite order Agnostida Salter, 1864: an Australian perspective. *Bur. Miner. Resour., Geol. Geophys. Aust. Rep.* 296: 1–93.
- TAYLOR, B.L., 1954: Progress Report on the North Pieman Mineral Area. Unpubl. rep. Tasm. Dep. Mines.
- TULLBERG, S.A., 1880: *Agnostus-artena i de Kambriska aflagringarne vid Andrarum. Sveriges Geologiska Undersökning. Avhandlingar* C42:1–37. [In Swedish.]
- TURNER, N.J., BROWN, A.V., MCCLENAGHAN, M.P. & SOETRISNO, I., 1991: *Corinna, Tasmania*. Tasm. Dep. Mines Geol. Atlas 1:50 000 Series, Sheet 7914N.
- WESTERGÅRD, A.H., 1947: Supplementary notes on the Upper Cambrian trilobites of Sweden. *Sveriges Geologiska Undersökning. Avhandlingar* C489: 1–35.
- WHITEHOUSE, F.W., 1936: The Cambrian faunas of north-eastern Australia. Parts 1 and 2. *Mem. Qld Mus.* 11: 59–112.

(accepted 6 December 1991)



## THE BENTHIC MACROFAUNA OF SLUDGE-AFFECTED SEDIMENTS IN THE DERWENT ESTUARY, SOUTHERN TASMANIA

by Pierre Horwitz and Greg Blake

(with two tables and three text-figures)

HORWITZ, P. & BLAKE, G., 1992: (31:x): The benthic macrofauna of sludge-affected sediments in the Derwent estuary, southern Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 67–72. ISSN 0080–4703. Centre for Environmental Studies, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001.

The paper reports the findings of an extensive survey of benthic invertebrates from the Derwent estuary in southern Tasmania, sampled during an investigation into the distribution and character of sludge emanating from a pulp and paper factory. In total, 45 invertebrate species were collected, but none was found in the sediment in the river channel between the pulpmill (its effluent outfall) and a site 5 km downstream. Similarly, other sediments with wood fibre present (measured by loss on ignition) and with very negative redox values were faunistically depauperate and possessed much lower species richness than that anticipated from other studies in Australia. The sediments in shallow areas in the middle part of the estuary had very high densities of invertebrates and had less mechanical wood fibre than sediments in deeper water nearby or other sediments further downstream. These results suggest that smothering by wood fibre, with concomitant toxicological effects of chemical reactions in the sediment, results in the low invertebrate diversities observed. These findings must be tempered by the methodological limitations involved with the selection of sample sites and lack of seasonal data, which have prevented definitive statements from being made about the level of environmental stress being experienced in the lower parts of the estuary.

**Key Words:** benthic macrofauna, sludge, estuary, Tasmania.

### INTRODUCTION

The Derwent River is one of the largest river systems in Tasmania, arising in the wetter, western portion of the Central Highlands and flowing in a southeasterly direction to its estuary, on which Hobart is situated. Here, the estuary is regarded as a “highly stratified salt-wedge/partially mixed estuarine system ...” (Davies & Kalish 1989). The salt-wedge moves backwards and forwards over approximately 10 km of the upper estuary, depending on the freshwater inflows. At the inland extension of the salt-wedge, a pulp and paper manufacturer, Australian Newsprint Mills Ltd (ANM), has its effluent outfall, and in the past huge quantities of mechanical wood fibre and other organic materials have flowed from this source. Further downstream, beyond the area of salt-wedge movement, two other major industries have their effluent inputs, namely a chocolate factory and a zinc refinery. Over the length of the estuary, about a dozen sewerage plants have their outlets, and numerous stormwater drains empty into it, mainly via the rivulets. Concerns for its environmental quality were highlighted by a heavy metal concentration study, which led to claims of heavy contamination (Bloom & Ayling 1977). These concerns have continued to be raised and were greatly exacerbated in late 1988 by the occurrence of rafts of foul-smelling organic material floating downriver and depositing on foreshore areas (Anon. 1989); this material is now referred to as “sludge” and its appearance on the householders’ doorstep prompted government- and industry-sponsored research (Anon. 1989; this study).

In the past, marine benthic invertebrate communities have been used as indicators of environmental stress (e.g. Gray 1981 and Warwick 1986), but rarely has this type of work been applied to estuaries. One reason for this is that

estuaries are areas of stress for aquatic faunas, due to problems of osmotic regulation resulting from the large seasonal and tidal fluctuations in salinity (Kennish 1990). The result is a biota which is both resilient and opportunistic (McComb & Lukatelić 1986), with a characteristically patchy (in local distribution) macrofauna (Kennish 1990). Previous studies of estuarine benthic invertebrate faunas in Australia have covered urban areas (e.g. the Yarra River in Victoria – Poore & Kudenov 1978), suburban or largely agricultural estuaries (e.g. Poore 1982 – the Gippsland Lakes in Victoria; Jones *et al.* 1986 and Jones 1987 – the Hawkesbury system in NSW; Rainer 1981 – Port Hacking, NSW) or undisturbed estuaries (e.g. Edgar 1990 – the Port Davey/Bathurst Harbour estuary in Tasmania). All studies show patterns of invertebrate occurrences and densities with fluctuations in salinity, depth, substrate structure, temperature and other environmental parameters.

Detailed studies of the benthic invertebrate fauna of the Derwent estuary have not taken place; so far, studies have either concentrated on single species or groups, concentrating neither on the invertebrate ecology nor the impact of major environmental influences in the area, resulting in a lack of systematic surveys. Accordingly, the articles by Guiler (1955), and Spratt (1976) are limited in their usefulness. The most substantive study undertaken previously was that reported by Matthews (1979), in which 31 benthic species were recorded from samples taken over about a year in the upper estuary, but the “...unbalanced structure of the benthic data suggest(ed) a very stressed community ...”.

The present study aims not only to document the benthic invertebrate fauna in sludge-affected areas, but also to identify the most likely factors which influence the distribution and abundance of that fauna.

## MATERIALS AND METHODS

An Eckman Grab benthos sampler ( $0.15 \times 0.15 \times 0.15$  m) was used to collect samples of sediment. Sixty-nine locations were sampled during a programme designed to determine the distribution and character of sludge in the Derwent Estuary (see Garland *et al.* 1990). The locations are shown in figure 1.

Samples were collected between 0800 and 1600 hrs on the following days in 1990 (number of samples in parentheses): 21 Feb. (5), 22 Feb. (3), 2 Mar. (1), 6 Mar. (3), 7 Mar. (6), 8 Mar. (10), 9 Mar. (5), 19 Mar. (8), 20 Mar. (23) and 30 Mar. (5). More details about the locations, times and dates of the sampling are given in Garland *et al.* (1990).

At each sampling station, the depth of the water column was measured and adjusted to take into account the tidal variations in water height. The physicochemical parameters of pH, conductivity and redox potential were determined by placing respective probes (WTW instrumentation) into the sediment as soon as it was released by the grab.

At each site, three grab samples were taken and amalgamated into a large plastic bag, resulting in approximately 3 kg of sediment.

Samples were preserved immediately by the application of concentrated formalin to make a solution of approximately 10%, after which they were stored in plastic bags and transported to the laboratory. Each sample was washed

through a sieve of 500 mm mesh pore size to remove clay and silt and the material remaining in the sieve was then transferred to a white-background tray where it was carefully sorted. Animal material was picked out and placed in a solution of 70% ethanol. A reference collection of all species identified in the samples was made with the assistance of taxonomic experts for some groups (see Acknowledgements). (This collection will be lodged in the Tasmanian Museum and Art Gallery.)

The number of species found in each sample (species richness), or the number of individuals of each species (total abundance) in each sample were then plotted against the following parameters to examine the data for linear trends:

(i) conductivity (as a measure of salinity), redox potential and pH;

(ii) distance from Boyer as estimated from a map (Tasmap 1:25 000, Lands Department, Hobart) (by adding incrementally the distance from the previous relevant sampling station);

(iii) depth of water column at medium low tide;

(iv) organic content (as determined by % loss on ignition [LOI] at  $550^{\circ}\text{C}$  for two hours after initial drying at  $110^{\circ}\text{C}$ ); and

(v) % clay (= % kaolinite + % illite), and % quartz (determined by Fourier transform-infrared spectroscopy; see Garland *et al.* 1990).

Where relevant, parameters were transformed from percent to arcsin values for the determination of correlation

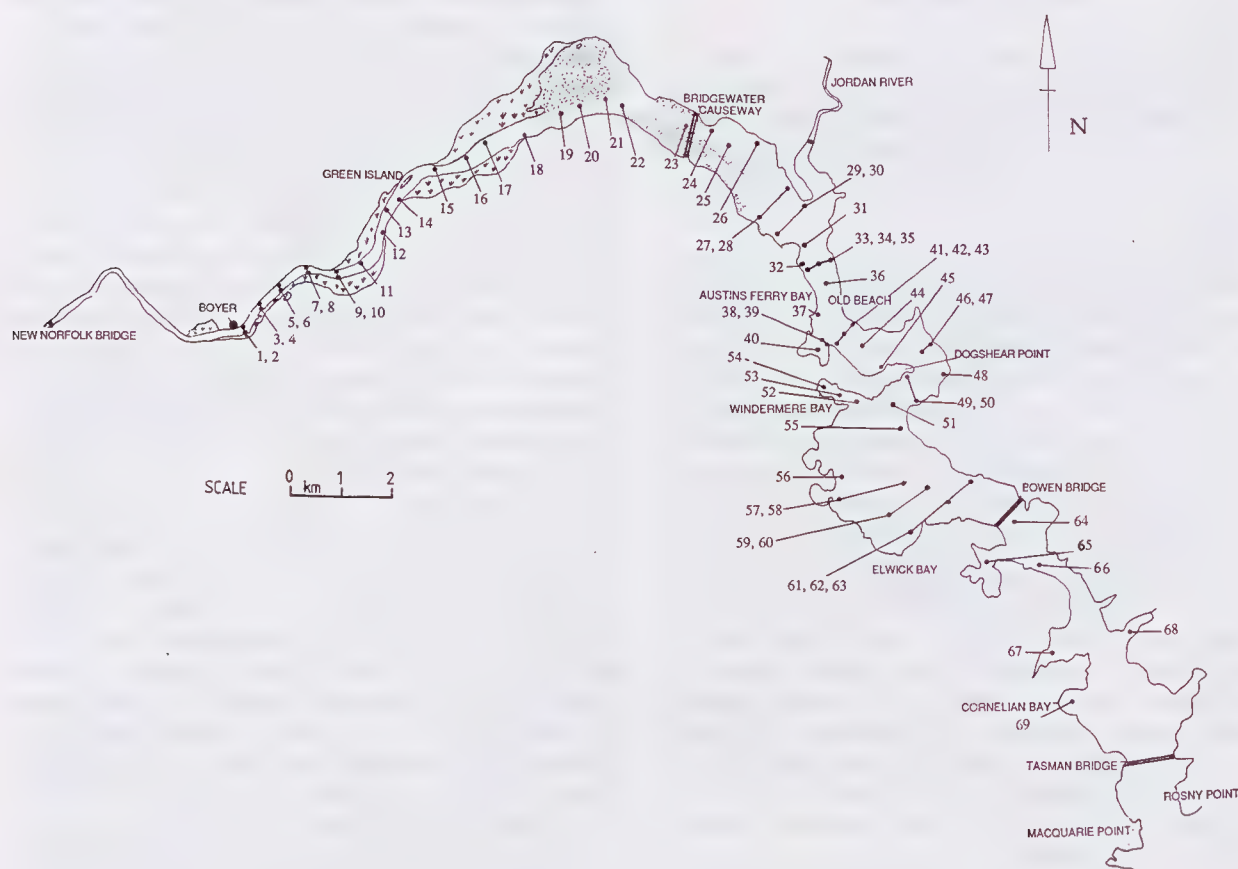


Fig. 1 — The Derwent estuary showing the location of the 69 sampling sites (•) with their code numbers, where detailed invertebrate analyses were undertaken.

coefficients and their significance levels (Zar 1974), using the statistical package *Statworks*.

## RESULTS

A total of 45 invertebrate and one vertebrate species was collected from the benthic samples (table 1; n.b. the number quoted is less than the "52" quoted in Garland *et al.* 1990, because of more detailed taxonomic study). None of the species could be regarded as belonging strictly to freshwater habitats, with the possible exception of chironomid (non-biting midge) larvae, and these were only found in samples in shallow water near Limekiln Point (table 1 and fig. 1). The most distant (from Boyer) samples contained several examples of predominantly marine species, such as the modocopid ostracods, polynoid polychaetes, nemerteans and sipunculans. The remaining species occurred commonly, sporadically or rarely throughout the estuarine area.

Two species were common and occurred in most samples, namely the spionid polychaete worm *Orthoprionospio cirriformia* and the bivalve mollusc (*Arthritica helmsi*). Both species were extremely abundant in a few samples; for instance, in sample 25, a total of 428 individuals of the former species, and 332 individuals of the latter, were found. These maximum densities corresponded to 6341 and 4919 individuals per m<sup>2</sup>. Three other species, two of them amphipod crustaceans (*Paracorophium* sp. and *Limnoporeia kingi*), and one gastropod mollusc (*Tatea rufilabris*) were the next most commonly encountered species in the samples.

Species richness ranged from 0 (no animals in the sample) to 22 (table 1; samples with no animals not included). All of the samples from the area between the ANM outfall at Boyer and 5 km downstream, in the so-called mixing zone, contained no fauna. The number of species found in each sample generally increased with distance downstream (fig. 2), so that the sample with the most species came from Cornelian Bay, the site which was both furthest from the source of mechanical wood fibre and closest to full marine conditions. These relationships are confirmed by the highly significant correlations between species richness and redox potential, and between species richness and LOI (table 2), because LOI in effect measures the amount of wood fibre in a sample, and the anaerobic conditions produced by wood fibre breakdown are reflected by lower (more negative) redox values.

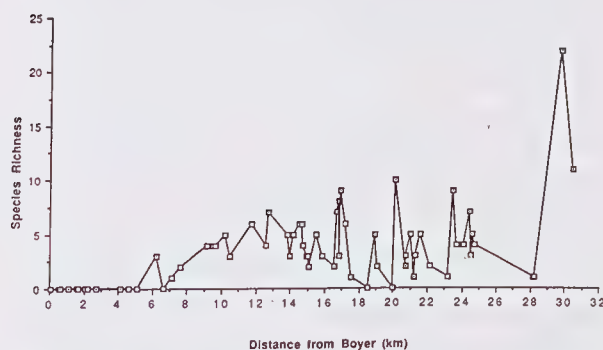


Fig. 2 — The number of species found in sediment samples as a function of distance from Boyer (the effluent outfall).

The highly significant correlation between pH and species richness (table 2) can also be explained by a combination of these relationships, so that

(i) sediments become more alkaline with an increasing marine influence in an estuary, and the distance relationship described above for species richness might simply correlate with other variables (like pH) which vary over distance; and (ii) sediments become more acidic as organic material breaks down, releasing humic acids; the relationship between pH and species richness therefore reflects the species richness/LOI relationship and the presence of mechanical wood fibre in samples.

The total abundance of animals showed a similar pattern to the species richness in the mixing zone, where no, or very little fauna occurred up to 7.5 km from Boyer (fig. 3). However, a different pattern emerged downstream of the mixing zone (fig. 3), where major peaks in abundance occurred in sampling stations on either side of the Bridgewater causeway. These peaks appear to be associated with shallower areas where waters are of a lower salinity, since total abundance is significantly negatively correlated with both conductivity and depth (table 2); the shallower the water, and the lower the conductivity/salinity, the higher the total abundance (and *vice versa*). This relationship may also be influenced by an apparent absence of wood fibre, as evidenced by the very low values of LOI found for the shallow samples 25, 26, 27 and 29, where abundances were the highest found in the survey (table 1), and confirmed by the highly significant negative correlation between total abundance and LOI.

## DISCUSSION

A comparison of the Derwent estuary macrobenthic fauna found in this survey with that of other estuarine faunas demonstrates some conspicuous differences. The most profound of these is that only 45 invertebrate species were located in the Derwent compared with 248 species in the Yarra system (Poore & Kudenov 1978), 90 in the Gippsland Lakes region (Poore 1982), 340 in the Port Davey estuary (Edgar 1990), and 177 species in the Hawkesbury estuary (Jones 1987). These differences may be attributable to one or more of the following factors:

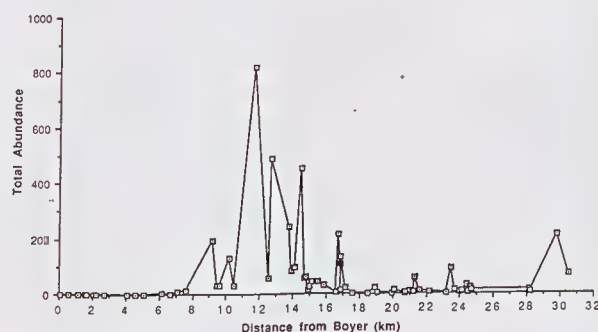


Fig. 3 — The total number of individuals found in sediment samples as a function of distance from Boyer (the effluent outfall).



Table 2  
The relationship (in terms of linear correlations) between species richness, total abundance, and various parameters of the sediment

|           |     | Depth           | Conductivity    | Redox*          | LOI*            | % clay <sup>†</sup> | % quartz | pH*             |
|-----------|-----|-----------------|-----------------|-----------------|-----------------|---------------------|----------|-----------------|
| Species   | (r) | 0.03            | 0.10            | 0.66            | 0.49            | 0.07                | 0.15     | 0.47            |
| Richness  | (n) | 69 ns           | 69 ns           | 65 <sup>§</sup> | 64 <sup>§</sup> | 58 ns               | 69 ns    | 65 <sup>§</sup> |
| Total     | (r) | 0.24            | 0.42            | 0.23            | 0.46            | 0.14                | 0.21     | 0.17            |
| Abundance | (n) | 69 <sup>‡</sup> | 69 <sup>§</sup> | 65 ns           | 64 <sup>§</sup> | 58 ns               | 69 ns    | 65 ns           |

r = correlation coefficient. n = sample size. (Total data set sample size = 69.) ns = not significant.

\* Values are missing at a few sampling stations.

<sup>†</sup> Values in the mixing zone have been excluded due to the trace quantities recorded.

<sup>‡</sup> Significant at the 0.05 level.

<sup>§</sup> Significant at the 0.001 level.

(1) The Derwent estuary may be naturally depauperate in its faunal composition, or it may be part of a biogeographical province in which estuaries are depauperate faunistically.

(2) The Derwent survey may not have sought a complete longitudinal profile of benthic invertebrates, including fully freshwater and/or marine species; these constitute a high proportion of taxa found in estuaries.

(3) Seasonal variations in the fauna were not examined for the Derwent but were incorporated in the other studies, so that species absent from the Derwent estuary in late summer would not be represented in samples.

(4) Spatial variations in the estuary were not sought, so that obvious habitat variations, where the faunal composition might well have been different, were deliberately not sampled and, in fact, the sampling programme was designed to concentrate approximately two-thirds of the samples in sediments showing evidence of sludge.

(5) There were other differences in the sampling methodology in the studies (for instance, grab samples in this study compared to artificial substrates in Edgar (1990), and other methods more likely to collect very rare species).

(6) Environmental stress (i.e. pollution) may be more severe in the Derwent than in the other estuaries, resulting in the elimination of species, or rendering them very rare and unlikely to be detected in such a survey.

None of these possible explanations can be discarded as unlikely. The first is impossible to test, in the absence of baseline data (faunal lists) on the Derwent estuary prior to the development of the Hobart metropolitan area and the introduction of major pollutants, and in the absence of data from nearby estuaries such as the Huon estuary.

The longitudinal distribution of invertebrates in an estuary is somewhat characteristic, with species richness decreasing as salinities rise at first, but then showing a tendency to increase markedly with further salinity rises to full seawater concentrations (see Kennish 1990). Thus, by not sampling the extremes where the majority of taxa are found, this study could have seriously underestimated the total number of species present in the estuary. For instance, no samples were taken from above the effluent outfall at Boyer (corresponding to, coincidentally, the upper extremity of the inland penetration of the salt-wedge). Despite the decreased species richness in the middle parts of an estuary, the density of the taxa present there can be great; these high

abundances are often attributed to the reduction in the number of species competing for a limited food supply (Kennish 1990). The high abundances found in this study, around the naturally-occurring mud flats and shallower areas on both sides of the Bridgewater causeway, may be due in part to this tendency, apparently unaffected by the mechanical wood fibre which is carried in deeper parts of the estuary.

Points 3, 4 and 5 above, represent the most serious methodological limitations of the present study. They cannot be tested without further surveys in other seasons and in habitats not actively sought in this study, such as in seagrass communities and on hard substrata, and by using a variety of collecting techniques.

The question of environmental degradation in the Derwent is obviously the focus of this work. Traditional methods of examining benthic samples and estimating environmental stress, such as selecting a faunal group which is known to be sensitive to pollution, recording deviations of the log-normal distribution, or using the abundance/biomass comparison method (Meire & Dereu 1990) are all inappropriate in this case. This is because of the lack of prior knowledge of the fauna, the large number of samples which were totally devoid of species, and the small number of samples taken at each station (thereby reducing the replicability). In addition, the samples were collected from across an ecocline from the inland intrusion of a salt-wedge to a predominantly marine situation. Only the incidental observations of the most common species are useful in this regard: *Orthophrionospio cirriformia* occurs in places in very high densities, sometimes in the presence of mechanical wood fibre and the absence of other benthic invertebrates, and it appears to be able to tolerate highly negative levels of redox potential. The presence of one or two small opportunistic species, which are both numerical and biomass dominants is strong circumstantial evidence for a disturbance (i.e. pollution perturbation) in a community (Warwick 1986).

The presence of extensive sediment samples with a series of environmental variables, indicative of environmental degradation, allows a number of postulations to be made regarding the benthic fauna of the Derwent, and these can be used in the future as the hypotheses for more detailed analysis. Thus:

(1) The strong correlations between species richness, redox and LOI indicate that the presence of wood fibre, with its concomitant smothering effect, and reduction of sediments, due to action of anaerobic bacteria, result in an often complete faunal eclipse, not only in deeper but also in surface portions of the sediment. In addition, sediments which are strongly reducing convert mercury into a methylated form (So 1979) which is extremely toxic to animal life. Thus, sediments with wood fibre and heavy metals, like mercury, may act as a significant deterrent to most potential colonising invertebrates, as well as being toxic to those already occupying them.

(2) The very high densities of invertebrates on either side of the Bridgewater causeway appear to be related to the shallow depth of the water, in which sediments had a lower conductivity and a comparatively lower wood fibre content. These high densities of invertebrates have significant conservation value. Extensive bird colonies (Blackhall 1988) utilise the food resources in these high density areas. Any change to the buoyancy of effluent from ANM at Boyer, or nutrient status of the upper Derwent estuary, may have a significant detrimental effect on the shallow water ecology in these areas.

(3) On the basis of the present study the effects of other sources of pollution well below Dogshear Point cannot be dissociated from the effects of the presence of mechanical wood fibre, even though many of the sites sampled have clearly depauperate faunal communities and often high levels of mechanical wood fibre.

## ACKNOWLEDGEMENTS

This work formed part of the Derwent River Sludge Study, funded by the Department of Environment and Planning, Pasminco Ltd and Australian Newsprint Mills Ltd.

We are most grateful to those researchers who kindly identified invertebrates, namely Liz Turner (Mollusca), Robin Wilson (Polychaeta), Russell Hanley (Polynoidae), Alison Green (brachyuran crustaceans), Gwen Fenton (mysid crustaceans) and Gary Poore (Amphipoda, Tanaidacea, Cumacea). Andrew Dumphy helped with sample sorting. The Marine Board of Hobart provided information on tides and water heights. Selection of sampling sites and coordination of the collection of samples was undertaken by Christian Garland. We appreciate the critical comments of Graham Edgar on an earlier version of the manuscript.

## REFERENCES

- ANON., 1989: *DERWENT RIVER SLUDGE STUDY PHASE 1. Tech. Rep. Dep. Environment*, Hobart.
- BLACKHALL, S.A., 1988: A survey to determine waterbird usage and conservation significance of selected Tasmanian wetlands State II. *Occ. Pap.* 16 Dep. Wildl. Heritage, Hobart.
- BLOOM, H. & AYLING, G.M., 1977: Heavy metals in the Derwent estuary. *Environ. Geol.* 2: 3–22.
- DAVIES, P.E. & KALISH, S., 1989: Water quality of the upper Derwent estuary, Tasmania. *Occ. Rep.* 89–03, Inland Fisheries Commission.
- EDGAR, G., 1990: Hydrological and ecological survey of the Port Davey/Bathurst Harbour estuary 1988–1989. Rep., Tasm. Dep. Parks, Wildl. & Heritage.
- GARLAND, C., HORWITZ, P. & HOLLOWAY, P.E., 1990: Distribution and characterisation of wood fibre-rich sludge in the Derwent River estuary. *DERWENT RIVER SLUDGE STUDY PHASE 2*, vol. 2B. *Tech. Rep. Dep. Environ.*, Hobart.
- GRAY, J.S., 1981: Detecting pollution-induced changes in communities using the log-normal distribution of individuals among species. *Mar. Poll. Bull.* 12: 173–176.
- GUILER, E.R., 1955: Observations on the hydrology of the River Derwent, Tasmania. *Pap. Proc. R. Soc. Tasm.* 89: 65–80.
- JONES, A.R., 1987: Temporal patterns in the macrobenthic communities of the Hawkesbury Estuary, New South Wales. *Aust. J. Mar. Freshw. Res.* 38: 607–624.
- JONES, A.R., WATSON-RUSSELL, C.J. & MURRAY, A., 1986: Spatial patterns in the macrobenthic communities of the Hawkesbury Estuary, New South Wales. *Aust. J. Mar. Freshw. Res.* 37: 521–543.
- KENNISH, M.J., 1990: *ECOLOGY OF ESTUARIES. VOLUME II. BIOLOGICAL ASPECTS*. CRC Press, Boston.
- MATTHEWS, J.H., 1979: An investigation of the effects of the effluent from ANM on the upper Derwent estuary. Unpubl. rep., ANM Ltd, Boyer, Australia.
- MCCOMB, A.J. & LUKATELICH, R.J., 1986: Nutrients, and plant biomass in Australian estuaries, with particular reference to south-western Australia. *AUSTRALIAN LIMNOLOGY*. CSIRO, Melbourne/Junk, Dordrecht.
- MEIRE, P.M. & DEREU, J., 1990: Use of the abundance/biomass comparison method for detecting environmental stress: some considerations based on intertidal macrozoobenthos and bird communities. *J. Appl. Ecol.* 27: 210–223.
- POORE, G.C.B., 1982: Benthic communities of the Gippsland Lakes, Victoria. *Aust. J. Mar. Freshw. Res.* 33: 901–915.
- POORE, G.C.B. & KUDENOV, J.D., 1978: Benthos of the Port of Melbourne: the Yarra River and Hobsons Bay, Victoria. *Aust. J. Mar. Freshw. Res.* 29: 141–155.
- RAINER, S., 1981: Temporal patterns in the structure of macrobenthic communities of an Australian estuary. *Estuarine, Coastal and Shelf Science* 13: 597–620.
- SO, C.L., 1979: Mercury–water interactions in the estuarine environment. *Mar. Poll. Bull.* 10: 334–337.
- SPRATT, P., 1976: An investigation of the estuary of the Derwent River with predictive reference to the mid-littoral zone of the rocky shores on each bank. Centre for Environmental Studies, University of Tasmania.
- WARWICK, R.M., 1986: A new method for detecting pollution effects on marine macrobenthic communities. *Mar. Biol.* 92: 557–562.
- ZAR, J.H., 1974: *BIOSTATISTICAL ANALYSIS*. Prentice-Hall, New York.

(accepted 6 December 1991)

## A NEW NOTOSPIRIFERINE GENUS (SPIRIFERIDA: BRACHIOPODA) FROM THE PERMIAN OF TASMANIA

by M.J. Clarke

(with one text-figure and one plate)

CLARKE, M.J., 1992 (31:x): A new notospiriferine genus (Spiriferida: Brachiopoda) from the Permian of Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 73–76. ISSN 0080–4703. Geological Survey of Tasmania, PO Box 56, Rosny Park, Tasmania, Australia 7018.

*Farmerella exoporosa* gen. et sp. nov. is described from cold-water Permian (Bernacchian–Lymingtonian) rocks of Tasmania. The new taxon is essentially homeomorphic with *Glendonia* McClung & Armstrong, 1978. However, *Glendonia* possesses a micro-ornament of low, elongate microspines behind shallow, elongate grooves, whereas *Farmerella* gen. nov. (as in *Notospirifer* Harrington, 1955) has deep, elongate and globose pits which penetrate the thickened outer primary shell layer but not the inner shell layer. This feature suggests that *Notospirifer* and *Farmerella* gen. nov. are closely related and should be assigned to a separate subfamily, the Notospiriferinae Archbold & Thomas, 1986 (emended herein), and *Glendonia*, *Birchsella* Clarke, 1987 and *Kelsovia* Clarke, 1990 to a separate subfamily, the Glendoniinae nov. The areal and stratigraphical distributions, and evolutionary relationships of the various genera are briefly discussed.

**Key Words:** Permian, cold-water, spiriferid brachiopod, new taxon, Tasmania.

### INTRODUCTION

*Spirifer darwini* Morris, 1845, the type species of *Notospirifer* Harrington, 1955 and *Spirifer (Brachythyris) duodecimcostata* M'Coy, 1847, both from the Permian Muree Sandstone at Glendon, New South Wales (Armstrong 1969), are two of the earliest fossil taxa described from Australia. Both species are small- to medium-sized spiriferids with short hingelines, rounded cardinal extremities, well-developed fastigia and sulci, and prominent lateral plications. In *Notospirifer darwini* the lateral plications are low and rounded, the sulcus is bald, and the fastigium is flattened or bears a shallow median groove, whereas in *S. duodecimcostata* the lateral plications are more acute and subangular, and both the fastigium and sulcus bear a strong median plication. Dorsal adminicula are present in *S. duodecimcostata* but absent in *N. darwini*. Furthermore, the micro-ornament of *S. duodecimcostata* consists of low, elongate microspines behind shallow, elongate grooves, whereas that of *N. darwini* consists of tiny upright microspines behind short grooves leading anteriorly into deep, globose and elongated pits, which penetrate the thickened outer primary shell layer but not the inner shell layer (Armstrong 1970). For these reasons, *S. duodecimcostata* and related species have been referred to a separate genus, *Glendonia* McClung & Armstrong, 1978. *Birchsella* Clarke, 1987 and *Kelsovia* Clarke, 1990 are two related genera, which are externally homeomorphic with *Notospirifer* in gross shell morphology but differ in internal details and possess low, elongate microspines behind shallow, elongate grooves, as in *Glendonia*. *Farmerella* gen. nov. is introduced herein to embrace those forms which are essentially homeomorphic with *Glendonia* in gross external and internal morphology, but possess deep, globose pits in the thickened outer primary shell layer as in *Notospirifer*.

The fundamental differences in micro-ornament and shell structure between *Notospirifer* and *Farmerella*, on the one hand, and *Glendonia*, *Kelsovia* and *Birchsella*, on the other, suggest that the two groups should be assigned to separate subfamilies, the Notospiriferinae Archbold & Thomas, 1986 (emended herein) and Glendoniinae nov. respectively.

All five genera occur in Tasmania, which appears to be the principal colonisation area; three genera occur in

Queensland, and two in New South Wales and New Zealand. They are unknown outside the eastern Australian and New Zealand (Australasian) Province of the Gondwanan Realm.

### SYSTEMATIC PALAEONTOLOGY

Phylum BRACHIOPODA Dumeril, 1806

Class ARTICULATA Huxley, 1869

Order SPIRIFERIDA Waagen, 1883

Family INGELARELLIDAE Campbell, 1959

Subfamily NOTOSPIRIFERINAE Archbold & Thomas, 1986 (emended herein)

#### Diagnosis

Small- to medium-sized shells; hingeline short, cardinal extremities rounded; fastigium and sulcus well developed, sometimes with a strong median plication; lateral slopes with well-marked, broadly rounded or more pronounced subangular plications; ventral interiors with dental plates and supporting adminicula, and little or no posterolateral secondary thickening; dorsal interiors with striate cardinal process, with or without adminicula (tabellae); shell surface with minute suberect microspines behind very short surface grooves leading anteriorly into deep, elongate and globose pits, which penetrate the thickened outer primary shell layer but do not penetrate to the valve interior. The only known genera are *Notospirifer* and *Farmerella* gen. nov.

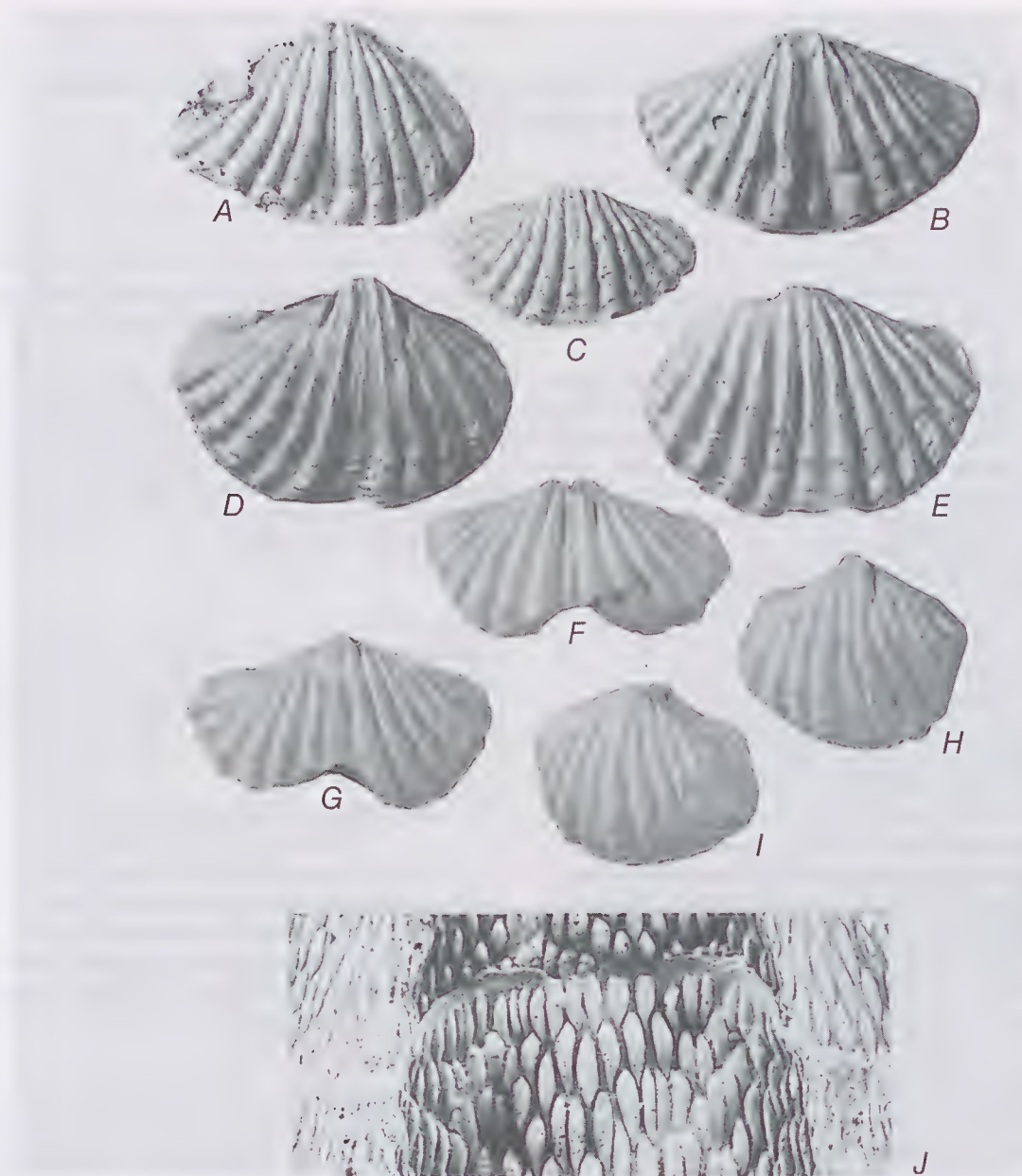
Genus *Farmerella* nov.

#### Etymology

After the late Dr N. Farmer, in recognition of his outstanding contribution to the understanding of the stratigraphy of Tasmanian Late Palaeozoic rocks.

#### Type species

*Farmerella exoporosa* sp. nov.



## PLATE 1

*Farmerella exoporosa* gen. et sp. nov. (A) Latex cast of ventral valve exterior GST 15501. (B) Ventral valve internal mould GST 15502. (C) Latex cast of dorsal valve exterior GST 15503. (D-E) Ventral and dorsal views of complete internal mould GST 15504. (F-G) Ventral and dorsal views of complete internal mould GST 15500. (H-I) Ventral and dorsal views of complete internal mould GST 15505. (J) External mould of dorsal valve showing the deep pits in relief GST 15506. GST 15500 is the holotype, all other specimens are paratypes. All figures are natural size except J, which is  $\times 20$ .

## Diagnosis

Forms essentially homeomorphic both externally and internally with *Glendonina*, but with tiny blunt microspines behind short surface grooves which lead anteriorly into deep, globose pits in the thickened outer primary shell layer.

*Farmerella exoporosa* sp. nov. (pl. 1A-J)

1985 *Notospirifer* sp. nov. (coarsely plicate species), Clarke (Farmer 1985: 35).

1991 Gen. nov. B, Clarke (1991: 64-65, fig. 5).

## Material

*Holotype* GST 15500 A-B, a complete internal mould and part counterpart external mould; paratypes GST 15501-10, various complete and incomplete internal moulds and incomplete external moulds; also over twenty other specimens, all from the lower part (early Middle Lymingtonian-*Tomiopsis brevis* Zone) of the Deep Bay Formation (Unit 30D, Farmer 1985: 101) at EN083152, Deep Bay, Cygnet. GST 15511 A-B, complete internal mould and part external mould, from Deep Bay Formation, South Bruny Island at EN222022, and GST 15512 A-B, complete internal mould and part external mould, from Poatina Group temporarily exposed in Hydro Electric

Commission Fisher Tunnel, Fisher River area at DP442867. Specimens from a lower stratigraphical interval (Early Bernacchian) are known from the lower part of the Hickman Formation, Harts Hill, Margate at EN203342, and the Rays Hills Arkose (Walker 1957), Cheeseberry Hill, near St Marys, northeastern Tasmania at EQ997004.

#### Description

Shell small- to medium-sized, biconvex, of typical spiriferid form but with subrounded cardinal extremities; hingeline short, considerably less than maximum shell width; fastigium and sulcus well developed, each with a pronounced median plication; flanks of both valves with up to seven coarse, subangular plications on each side; ventral interior with well-developed dental plates and supporting adminicula, with little or no posterolateral secondary thickening; dorsal interior with striate cardinal process and short, but well-developed adminicula or tabellae, which are about one-fifth to one-sixth of the length of the valve; outer primary shell layers much thickened, with tiny, blunt microspines behind short surface grooves which lead anteriorly into deep, globose pits.

#### Remarks

*Farmerella exoporosa* and *Glendonina duodecimcostata* are two remarkable, homeomorphic forms, which differ only in their surface micro-ornament and fundamentally distinct shell micro-structure. The latter character in *Farmerella* indicates a close relationship with *Notospirifer*. The adminicula show some variation in their development. In the holotype (pl. 1F–G), and in most specimens they occur between the first and second lateral plications. In others (pl. 1D–E, H–I) they occur between the second and third lateral plications, and in another (pl. 1B) they occur along the crest of the second lateral plications.

#### Occurrence

*Farmerella exoporosa* is relatively common at the type locality and from similar stratigraphical intervals (early Middle Lymingtonian–*Tomiopsis brevis* Zone), Deep Bay Formation, northwest of Poverty Point, Cygnet at EN038149, and South Bruny Island. Rare specimens were collected from temporary exposures of the Poatina Group in the Hydro Electric Commission Fisher Tunnel (Clarke & Farmer 1973). It is also known from the lower part of the Hickman Formation at Harts Hill, near Margate (Farmer 1985) in beds of Early Bernacchian (*Tomiopsis branxtonensis* Zone) age, and from beds of a similar or slightly younger age at Cheeseberry Hill, near St Marys, northeastern Tasmania.

#### Subfamily GLENDONIINAE nov.

#### Diagnosis

As for *Notospiriferinae*, but shell surface with low, elongate microspines behind shallow, elongate grooves; thickened outer primary shell layer with deep, globose pits absent. Dorsal valve adminicula are present in *Glendonina* and *Kelsovia* but absent in *Birchsella*, which also has very heavy posterolateral secondary thickening in the ventral valve.

### DERIVATION AND DISTRIBUTION

All five genera may have been derived from the genus *Tomiopsis* Benediktova, 1956, which occurs abundantly

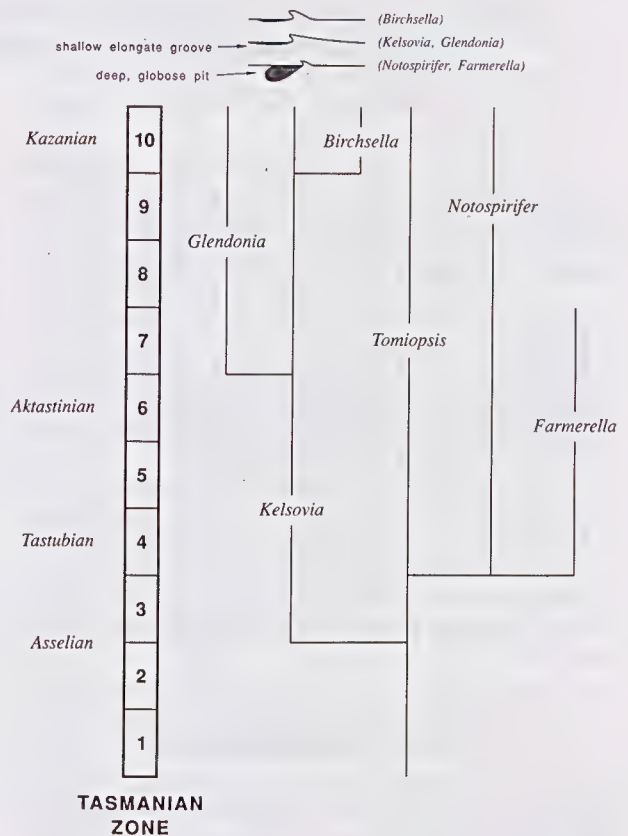


FIG. 1 — Inferred ingelarellid phylogeny and stratigraphical distributions within Tasmania.

throughout the Permian of eastern Australia and New Zealand, by a process of change in shell form, variable modification of the micro-ornament and variable loss of the dorsal adminicula (fig. 1).

*Kelsovia* is the oldest known genus which makes its appearance in Late Tamarian (Asselian) rocks in Tasmania with the type species *Kelsovia superba*. Younger species include *Notospirifer undulatus* Parfrey, 1986 and *Notospirifer?* sp.nov. McClung & Armstrong, 1978, both from Queensland, and *Kelsovia* sp.nov. from the Kazanian of Tasmania. It is unknown in New South Wales and New Zealand.

*Notospirifer* probably derived independently from a parent *Tomiopsis*, whereby the primary shell layer is thickened and the shallow, elongate, cigar-shaped grooves of *Tomiopsis* develop into deep, globose pits. The oldest species, *Notospirifer* sp.nov. from the Tastubian of Tasmania, has dorsal adminicula, but in all younger species they are absent. *Notospirifer* sp.nov. appears to be the true ancestral *Notospirifer*, in that some specimens show the repeated progressive modification of a *Tomiopsis* micro-ornament into a *Notospirifer* micro-ornament on successive major growth increments. *Notospirifer* is widely distributed throughout the Permian sequence of eastern Australia and occurs in rocks as young as Kazanian in Tasmania, New South Wales and Queensland.

Species of so-called *Notospirifer* from New Zealand (Waterhouse 1964 *et seq.*) need to be reassessed. Waterhouse (1967) appeared to confuse the two Glendon species

*Notospirifer darwini* (Morris) and *Glendonina duodecimcostata* (M'Coy). The micro-ornament said to characterise *Notospirifer* by Waterhouse (1967) belongs with *Glendonina* (Armstrong 1969, McClung & Armstrong 1978, Clarke 1987). Nevertheless, *N. macropustulosus* Waterhouse 1968 is a true *Notospirifer*, whereas the holotype, at least, of *N. microstriatus* Waterhouse 1964 belongs in *Glendonina* (Campbell & Clarke, in prep).

*Farmerella*, which only occurs in Tastubian–Aktastinian rocks in Tasmania, may be derived from *Notospirifer* by an increase in the strength of the lateral plications and the development of a strong median plication in both the fastigium and sulcus. More probably it derived independently from a *Tomioopsis* ancestor, since dorsal adminicula are retained.

*Birchsella* is known only from Kazanian rocks in Tasmania, and appears to be a later derivative of *Kelsovia*, whereby the dorsal adminicula atrophy and the ventral valve develops heavy posterolateral secondary thickening.

*Glendonina*, which occurs widely in Tasmania, New South Wales and Queensland in Aktastinian–Kazanian rocks, is probably derived from *Kelsovia* by an increase in the strength of the lateral plications and the development of a strong median plication in both the fastigium and sulcus. Dorsal adminicula are retained, as in the ancestral *Kelsovia* (and *Tomioopsis*).

## ACKNOWLEDGEMENTS

I thank E.L. Martin and W. Jablonski for taking the photographs and E. Williams and S.M. Forsyth for critically reading the manuscript which was typed by Anne Taylor. H.J. Campbell kindly provided access to some New Zealand material. The author publishes with the permission of the Geological Survey of Tasmania.

## REFERENCES

- ARCHBOLD, N.W. & THOMAS, G.A., 1986: Permian Ingelarellidae (Brachiopoda) from Western Australia and Argentina. *J. Paleont.* 60(3): 581–605.
- ARMSTRONG, J.D., 1969: The martiniacean species occurring at Glendon, New South Wales, the type locality of *Notospirifer darwini* (Morris). *J. Proc. R. Soc. NSW* 101: 197–204.
- ARMSTRONG, J.D., 1970: Micro-ornaments of the spiriferid brachiopods *Notospirifer*, *Ingelarella* and *Subansiria*. *Lethaia* 3: 287–300.
- BENEDIKTOVA, R.N., 1956: Spiriferidy Ostrogskei svity Kuzbassa. *Voprosy Geologii Kuzbassa, Materialy vtorogo soveschinya po stratigrafi uglenosnykh otlozhenii* 1: 169–182.
- CAMPBELL, K.S.W., 1959: The *Martiniopsis*-like spiriferids of the Queensland Permian. *Palaeontology* 1: 333–350.
- CAMPBELL, H.J. & CLARKE, M.J., in prep. A revision of New Zealand *Notospirifer* and related forms.
- CLARKE, M.J., 1987: Late Permian (late Lymingtonian = ?Kazanian) brachiopods from Tasmania. *Alcheringa* 11: 261–289.
- CLARKE, M.J., 1990: Late Palaeozoic (Tamarian; Late Carboniferous–Early Permian) cold-water brachiopods from Tasmania. *Alcheringa* 14: 53–76.
- CLARKE, M.J., 1991: *Notospirifer* Harrington, 1955 and related spiriferid genera from the Permian of eastern Australia and New Zealand. In Mackinnon, D.I., Campbell, J.D. & Lee, D.E. (Eds): *BRACHIOPODS THROUGH TIME*. Proc. 2nd Int. Brachiopod Congr., Dunedin, New Zealand 1990. Balkema, Rotterdam: 63–66.
- CLARKE, M.J. & FARMER, N., 1973: The Fisher Tunnel Permian section and its relation to the Kansas Creek section, Tasmania. *Tasm. Dep. Mines Tech. Rep.* 16: 41–49.
- FARMER, N., 1985: *Kingborough, Tasmania*. Tasm. Dep. Mines 1:50 000 Geol. Atlas Ser., Explan. Rep., Sheet 88.
- HARRINGTON, H.J., 1955: The Permian *Eurydesma* fauna of eastern Argentina. *J. Paleont.* 29: 112–128.
- MCCLUNG, G. & ARMSTRONG, J.D., 1978: Species of *Glendonina* (Ingelarellinae–Spiriferida) in the Permian of eastern Australia. *Palaeont. Pap. No. 39, Geol. Surv. Qld Pub.* 365: 1–5.
- M'Coy, F., 1847: On the fossil botany and zoology associated with the coal of Australia. *Ann. Mag. Nat. Hist.* 20: 145–157, 226–236, 298–312.
- MORRIS, J., in Strzelecki, P.E. de, 1845: *PHYSICAL DESCRIPTION OF NEW SOUTH WALES AND VAN DIEMENS LAND*. Longman, Brown, Green and Longman, London: 270–291.
- PARFREY, S.M., 1986: Early Permian invertebrates from the Camboon Andesite near Bileola, southeastern Bowen Basin. *Geol. Surv. Qld Pub.* 387: 57–67.
- WALKER, K.R., 1957: Geology of the St Helens–Scamander Area. *Pap. Proc. R. Soc. Tasm.* 91: 109–114.
- WATERHOUSE, J.B., 1964: Permian brachiopods of New Zealand. *New Zealand Geol. Surv. Paleont. Bull.* 35: 1–287.
- WATERHOUSE, J.B., 1967: The ornament of the Permian brachiopod *Notospirifer* Harrington, 1955. *J. Geol. Soc. Aust.* 14: 273–280.
- WATERHOUSE, J.B., 1968: The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. *Palaeontographica* A129: 1–94.
- WATERHOUSE, J.B., 1982: New Zealand Permian brachiopod systematics, zonation and paleoecology. *New Zealand Geol. Surv. Paleont. Bull.* 48: 1158.

(accepted 6 December 1991)

## A CHECKLIST OF THE TASMANIAN TORTRICID MOTHS (LEPIDOPTERA: TORTRICIDAE) AND THEIR HOST-PLANT RELATIONSHIPS

by P.B. McQuillan

MCQUILLAN, P.B., 1992 (31:x): A checklist of the Tasmanian tortricid moths (Lepidoptera: Tortricidae) and their host-plant relationships. *Pap. Proc. R. Soc. Tasm.* 126: 77–89. Plant Protection Branch, Department of Primary Industry, GPO Box 192B, Hobart, Tasmania, Australia 7001.

An annotated checklist of 165 described species of Tasmanian Tortricidae is presented. There is a single endemic genus, the monobasic *Symphygas*, and the genera *Coeloptera*, *Isotenes*, *Neohermenias* and *Tracholena* are recorded for the first time. At least 60 species (i.e. about one-third of the fauna) are endemic to Tasmania. The majority of species belong to the tortricine tribes Archipini (66 species) and Epitymbiini (49 species) while only 26 native species of Olethreutinae are recorded. Two species are introduced from Europe. The plant families Asteraceae and Myrtaceae are pre-eminent as foodplants. New foodplants are recorded for a number of species and the degree of monophagy is shown to be high. Foodplants are now known for about one-third of the fauna.

**Key Words:** Lepidoptera, Tortricidae, checklist, Tasmania, foodplants.

### INTRODUCTION

The Tortricidae are a large family of small moths (c. 5000 species worldwide) represented in most vegetated parts of the world. About 600 species of Tortricidae are named from Australia at present, but the total fauna may be double this number (Common 1980). The larvae, familiar as leaf-rolling caterpillars, characteristically form small shelters from leaves of their foodplant bound with silk, or bore into plant tissue. Collectively, a very wide range of plants are used as hosts but most foodplants are perennial shrubs or trees.

Several native Australian species, including the light-brown apple moth, the orange fruitborer and the macadamia nut-borer, have adopted new foodplants and become significant pests of agriculture, especially horticultural crops, causing economic losses domestically; they are therefore subject to quarantine barriers in export markets. Some others, such as the codling moth and the oriental fruit moth, are adventive with European man.

Despite the real and potential economic importance of the Tortricidae, there has been only a limited amount of systematic and biological work done on the Tasmanian fauna. Although Tasmania was a source of specimens for the early descriptive works of Walker (1863) and Meyrick (1881, 1910), the first and only available catalogue of species is that of Turner (1928) with its later supplement (Turner 1939) in which many species were assigned to European genera now known to be inappropriate. Since that time, a number of new species and occurrences have been discovered, and the generic and tribal classification of the family in Australia is much better understood. In recent years, the host-plant relationships of various species have been the subject of active research and have illuminated aspects as diverse as phylogeny and pest potential.

The purpose of this study was (i) to prepare a current annotated checklist of the species of Tortricidae known to be present in Tasmania, and (ii) to determine the foodplant relationships for as many species as possible. In view of the increasing diversity of Tasmanian horticultural products, such a study is timely and a necessary prerequisite for assessing quarantine risks.

### MATERIALS AND METHODS

A species checklist was prepared from field collections, museum specimens and from literature sources. The arrangement of genera and species within genera is alphabetical, pending better resolution of the phylogeny of the taxa; original generic assignments are in brackets and synonyms are indented. For many taxa, known relationships between them have not been formalised as genera and, instead, are referred to nominal species groups. These informal groupings are adopted with permission from the unpublished work of Dr I.F.B. Common, formerly of the CSIRO Division of Entomology, although some have been previously used in Powell & Common's (1985) study of oviposition behaviour.

Larvae were collected directly from the field and reared to adulthood on samples of their foodplants. Voucher specimens of moths are preserved at the New Town Research Laboratories of the Tasmanian Department of Primary Industry. Foodplant citations follow Buchanan *et al.* (1989). For categorising the degree of host specificity, the criteria of Powell (1980) were applied. Species recorded feeding on three or more plant families are regarded as polyphagous, those on two plant families as oligophagous, and as monophagous if on a single plant family.

Biological and habitat information is annotated directly to the checklist.

Broad definitions of habitats based on plant community structure are as follows:

*Rainforest* — tall closed forest typically dominated by *Nothofagus cunninghamii* and/or *Atherosperma moschatum*, with understoreys ranging from bryophytes/ferns to increasing complexity with shrubby Araliaceae (*Pseudopanax*), Epacridaceae (*Cyathodes*, *Prionotes*, *Trochocarpa*), Proteaceae (*Cenarrhenes*, *Orites*), Cunoniaceae (*Anodopetalum*, *Bauera*), Escalloniaceae (*Anopterus*), etc. Botanical diversity is relatively low in higher plants:

*Wet eucalypt forest* — tall sclerophyll forest dominated by *Eucalyptus regnans*, *E. obliqua*, *E. delegatensis*, *E. johnstonii* or *E. globulus* in rainfall regimes exceeding 1000 mm annually; understoreys may include ferns, Asteraceae (*Bedfordia*, *Helichrysum*, *Olearia*, *Senecio*), Epacridaceae (*Cyathodes*,

*Epacris*, *Richea*), Proteaceae (*Banksia*, *Lomatia*, *Orites*, *Telopea*), Fabaceae (*Acacia*, *Pultenaea*), Rhamnaceae (*Pomaderris*) and Rutaceae (*Phebalium*, *Zieria*).

**Dry eucalypt forest** — open sclerophyll forest to woodland dominated by various eucalypts, especially the peppermint group (e.g. *E. amygdalina* etc), sometimes with co-dominants such as *Acacia* and *Allocasuarina*; shrub and understorey species typically diverse and may prominently include Asteraceae (*Cassinia*, *Helichrysum*, *Olearia*), Campanulaceae (*Wahlenbergia*), Dilleniaceae (*Hibbertia*), Epacridaceae (*Astroloma*, *Epacris*, *Monotoca*), Fabaceae (*Acacia*, *Dillwynia*, *Pultenaea*), Goodeniaceae (*Goodenia*), Liliaceae (*Dianella*), Myrtaceae (*Leptospermum*), Pittosporaceae (*Billardiera*, *Bursaria*), Poaceae (*Danthonia*, *Poa*, *Stipa*, *Themeda*), Santalaceae (*Exocarpus*, *Leptomeria*), Sapindaceae (*Dodonaea*), Thymelaeaceae (*Pimelea*) and Xanthorrhoeaceae (*Lomandra*).

**Mixed forest** — incorporates elements of rainforest and wet eucalypt forest and, if undisturbed by fire, climaxes in rainforest due to shading of eucalypt seedlings. Botanical diversity can be high, and some shrubs such as Winteraceae (*Tasmania*) and Rutaceae (*Eriostemon*, *Zieria*) are typical. Coastal heath — developed on well-drained soils of the east and north coasts, including the Bass Strait islands; botanically diverse with major elements of Asteraceae (*Helichrysum*), Casuarinaceae (*Allocasuarina*), Dilleniaceae (*Hibbertia*), Epacridaceae (*Epacris*, *Leucopogon*, *Monotoca*), Fabaceae (numerous genera), Lauraceae (*Cassytha*), Myrtaceae (*Callistemon*, *Kunzea*, *Leptospermum*, *Melaleuca*), Polygalaceae (*Comesperma*), Proteaceae (*Banksia*, *Hakea*, *Persoonia*),

Rhamnaceae (*Spyridium*), and Thymelaeaceae (*Pimelea*); much of this flora at the species level is shared with southeastern Australia.

**Alpine heath** — developed on alpine plateaux generally above 1000 m altitude; botanically diverse at the species level and in growth form, and endemism high; well represented are Asteraceae (*Abrotanella*, *Helichrysum*, *Celmisia*, *Senecio*), Apiaceae (*Aciphylla*), Epacridaceae (*Archeria*, *Cyathodes*, *Dracophyllum*, *Epacris*, *Pentachondra*, *Richea*), Liliaceae (*Astelia*, *Milligania*), Myrtaceae (*Baeckea*, *Leptospermum*), Onagraceae (*Epilobium*), Plantaginaceae (*Plantago*), Proteaceae (*Bellendena*, *Grevillea*, *Orites*), Ranunculaceae (*Anemone*, *Ranunculus*), Rosaceae (*Acaena*, *Geum*, *Rubus*) and Scrophulariaceae (*Euphrasia*, *Ourisia*).

**Moorland heath** — developed on poorly-drained peaty soils of low nutrient status mainly at low to intermediate altitudes on modest topography in the south west; major monocot groups are Cyperaceae (especially button-grass, *Gymnoschoenus*) and Restionaceae, while shrubby dicots include Epacridaceae (*Epacris*, *Sprengelia*), Myrtaceae (*Baeckea*, *Callistemon*, *Leptospermum*, *Melaleuca*) and Proteaceae (*Banksia*). Fire prone.

Abbreviations used: ANIC, Australian National Insect Collection, Canberra; TFC Tasmanian Forestry Commission, Hobart; em — emerged; i — introduced to Tasmania; \* — endemic to Tasmania.

Unless otherwise stated, all voucher specimens are housed at the Department of Primary Industry Laboratories, Hobart.

## ANNOTATED CHECKLIST OF TASMANIAN TORTRICIDAE

Two subfamilies of Tortricidae occur in Tasmania.

### Subfamily TORTRICINAE

Five of the nine tribes recognised by Horak (1984) are represented in Tasmania.

#### AROTROPHORA group

The following genera constitute a unique Australian radiation reliant where known upon Proteaceae (Common 1963). Formerly associated with the tribe Cnephasiini, they are misplaced in this tribe based upon recent morphological (Powell & Common 1985) and biochemical (Horak *et al.* 1988) evidence. Their relationship to other Tortricidae remains unresolved.

##### *AROTROPHORA* Meyrick, 1881

Open forest to heathland, at elevations 0–1000 m. Eight species known from western, southern and eastern Australia. Known larvae are internal feeders in the flower spikes of *Banksia* (Common 1963), but *A. euides*, a Tasmanian endemic, is on *Lomatia*.

##### 1. *anemarcha* (Lower, 1902) (*Tortrix*)

Heathland and open forest. 0–200 m.

Foodplant: Proteaceae: *Banksia marginata* Cav., a low to tall shrub widespread in open forest and heathland from sealevel to over 1000 m.

3 km N of Eddystone Point, larva 16.ix.1985, em. 12.i.1986, P.B. McQuillan.

##### 2. *arcuatalis* (Walker, 1865) (*Scopula*)

*charistis* Meyrick, 1910

*submarginellus* (Walker, 1866) (*Crambus*)

*transcissella* (Walker, 1866) (*Eromene*)

Heathland and open forest. 0–1000m.

Foodplant: Proteaceae: *Banksia marginata* Cav.

Mt Wellington, 800 m, larva 14.xi.1988, em. 22.iii.1989, P.B. McQuillan.

##### 3. *euides* (Turner, 1927) (*Tortrix*)\*

Subalpine open woodland. 860–950 m.

Foodplant: Proteaceae: *Lomatia polymorpha* R. Br., a tall shrub in subalpine open woodland.

Reservoir Lakes near Mt La Perouse 860 m, larva 16.i.1988, em. 2.ix.1988, P.B. McQuillan.

This is the first record of this endemic species since the holotype collected on Mount Wellington in 1925. Larvae tie leaves to form a large frass-filled shelter. Common (1963) was uncertain of the generic placement of this species based upon male genitalic characters and the foodplant and feeding mode cast further doubt. Females, which might clarify the situation, remain unknown.

##### 4. *sinicosma* Turner, 1926 (*Arotrophora*). New record for Tasmania.

Coastal heathland.

Foodplant: Proteaceae: *Banksia marginata* Cav.

Nine mile beach, larva 1.v.1983, em. 16.xii.1983, P.B. McQuillan  
Asbestos Range National Park, larva 27.ix.1986, em. 4.xi.1986, P.B. McQuillan.

##### *PARAPHYAS* Turner, 1927

Wet sclerophyll forest. A single species in WA and Tasmania. Foodplant unknown.

##### 1. *callixena* Turner, 1927 (*Paraphyas*)

Wet sclerophyll forest.

##### *PERAGLYPHIS* Common, 1963

Wet and dry sclerophyll forest to heathland, at altitudes 0–1100 m. Fourteen Australian and one Indian species. Known larvae are leaf-tiers on Proteaceae such as *Banksia*, *Dryandra* and *Grevillea* (Common 1963). One mainland species is a minor pest of silky oak, *Grevillea robusta*.

1. *aderces* Common, 1963 (*Peraglyphis*)

Open forest.

2. *anaptis* (Meyrick, 1910) (*Arotrophora*)\*

Coastal heath.

3. *dyscheres* Common, 1963 (*Peraglyphis*)

Open forest.

4. *hemerana* (Meyrick, 1882) (*Arotrophora*)

Montane open forest.

5. *lividana* (Meyrick, 1881) (*Arotrophora*)

Open forest.

*SYLLOMATIA* Common, 1963

Sclerophyll forest to heathland. Three species in eastern Australia.  
Known larvae monophagous on *Lomatia* (Common 1963).

1. *pirastis* (Meyrick, 1910) (*Arotrophora*)\**castanea* (Meyrick, 1910) (*Arotrophora*)*pantoeodes* (Turner, 1939) (*Arotrophora*)

Open forest.

Foodplant: Proteaceae: *Lomatia tinctoria* R. Br., a low understorey shrub in open forest.

Ridgeway, larva 16.x.1988, em. 11.ii.1989, P.B. McQuillan.

Orford, larva 26.xi.1990, em. 2.iii.1991, P.B. McQuillan.

Larvae tie terminal leaves to form a shelter densely packed with frass.

2. *xythopterana* (Meyrick, 1881) (*Arotrophora*)*ammodes* (Meyrick, 1910) (*Arotrophora*)

Open forest.

*SYMPHYGAS* Common, 1963\*

Subalpine open forest, 950–1100 m. One species, endemic to Tasmania. Foodplant unknown.

1. *nephaula* (Meyrick, 1910) (*Tortrix*)\*

Subalpine open forest.

## Tribe PHRICANTHINI

A single genus is present in Tasmania. All known larvae feed on Dilleniaceae.

*SCOLIOPLECTA* Meyrick, 1881*NEUROSPADES* Turner, 1945

Dry sclerophyll forest to heathland at low altitudes. Seven species Australia-wide.

1. *comptana* (Walker, 1863) (*Sciaphila*)

Coastal heath to open eucalypt forest.

Foodplant: Dilleniaceae: *Hibbertia*

Notes: Eggs and oviposition pattern described by Powell & Common (1985).

2. *exochus* Common, 1965 (*Scolioplecta*)

Coastal heath.

## Tribe SCHOENOTENINI

All four Tasmanian genera belong to the *Proselena* group of genera recognised by Common (1965). *Tracholena* and *Syncratus* are allied to the New Zealand genus *Maoriteneas* "archetypic Schoenotenini" (Dugdale 1966). Known larvae in this group are monophagous internal feeders.

*PALAEOTOMA* Meyrick, 1881*TRACHYPTILA* Turner, 1916

Eucalypt forest. A monotypic genus widespread in southern Australia.

1. *stypelana* Meyrick, 1881 (*Palaeotoma*)*haplopolia* (Turner, 1945) (*Paraselena*)*melanosticha* (Turner, 1916) (*Trachyptila*)*melanosticha* (Turner, 1945) (*Acropolitis*)*pellochroa* (Turner, 1945) (*Lamyrodes*)

Wet and dry eucalypt forest.

Foodplant: Galls growing on Myrtaceae: *Eucalyptus* spp. (Common 1965).

*Eucalyptus amygdalina* Labill., leaf gall.

Blackmans Bay, em. 4.vii.1978, R. Bashford (TFC).

*Eucalyptus globulus* Labill., stem galls.

Bridgewater, em. 31.iii.1981, R. Bashford (TFC).

Lake Leake, larva 13.xi.1979, em. 22.xi.1979, R. Bashford (TFC).

*Eucalyptus viminalis* Labill.

Rose Bay, em. 10.vii.1981, R. Bashford (TFC).

Notes: Larvae are internal feeders, hollowing out galls.

*PROSELENA* Meyrick, 1881*PARASELENA* Meyrick, 1910

Open eucalypt forest. Two species in southeastern Australia.

1. *annosana* Meyrick, 1881 (*Proselena*)

Foodplant: Pittosporaceae: *Bursaria spinosa* Cav., an abundant tall shrub in dry sclerophyll forest.

Mt Nelson, 200 m, larvae in March 1986, failed to emerge but identified from Common (1965).

Young larvae are internal leaf-miners later forming a shelter from adjacent leaves spun together which are also mined.

*SYNCRATUS* Common, 1965

Wet eucalypt forest, mixed forest and rainforest. Two species in eastern Australia. Foodplant unknown.

1. *scepanus* Common, 1965 (*Syncratus*)

Wet eucalypt forest and mixed forest.

*TRACHOLENA* Common, 1965

Open forest. Three species in eastern Australia.

1. *sulfurosa* (Meyrick, 1910) (*Cnephasia*). New record for Tasmania. Open forest.

Foodplant: Native host probably Cupressaceae: *Callitris* spp., but recorded by Common (1965) from *Cupressus* in gardens.

Larvae tunnel in bark.

## Tribe ARCHIPINI (s. lat.)

A large tribe with larvae tying and consuming the live foliage of a wide range of plants; a minority are shoot borers or facultative borers in fruits.

*ACROPOLITIS* Meyrick, 1881

Wet and dry sclerophyll forests, at altitudes 0–1200 m. There is a strong association with live *Eucalyptus* and *Acacia* foliage but several species are polyphagous.

1. *dolosana* (Walker, 1863) (*Tortrix*)

Open forest.

2. *ergophora* Meyrick, 1910 (*Acropolitis*)

Subalpine open eucalypt forest. 860–1100 m.

Foodplant: Cunoniaceae: *Bauera rubioides* Andrews.

Lyell Highway, 1976, P. Geier (I.F.B. Common, pers. comm.)

Myrtaceae: *Eucalyptus coccifera* Hook. f.

Mt Wellington, 1100 m, larva 26.x.1988, em. 30.xii.1988, P.B. McQuillan.

Mt Field National Park, 1080 m, pupa 11.xi.1988, em. 7.xii.1988, P.B. McQuillan.

Santalaceae: *Exocarpos* sp.

Blackmans Bay, larva 29.x.1986, em. 17.xi.1986, R. Bashford (TFC).

Notes: Larvae tie 2 or 3 leaves of the foodplant in December-March. Specialisation on live young eucalypt leaves by archipines is unusual; competition for this resource from other moth and beetle larvae can be intense.

Larvae in the ACT recorded on Fabaceae: *Daviesia* by Horak *et al.* 1988.

3. *excelsa* Meyrick, 1910 (*Acropolitis*)  
Open forest.

4. *impletana* (Walker, 1863) (*Tortrix*)  
Wet and dry eucalypt forest.

5. *lignigerana* (Walker, 1863) (*Paedisca*)  
*inconcisana* (Walker, 1863) (*Sciaphila*)  
Wet and dry eucalypt forest.

6. *ptychosema* Turner, 1927\* (*Acropolitis*)  
Open forest.  
Foodplant: Myrtaceae: *Eucalyptus regnans* F. Muell.  
Briganti's Road, Florentine Valley, larva 3.iii.1980, em. 15.iv.1980, R. Bashford (TFC).  
*Eucalyptus delegatensis* R. Baker  
M.G. Road, Cygnet River, larva 13.vii.1981, em. 25.viii.1981, R. Bashford (TFC).  
*Eucalyptus amygdalina* Labill.  
Blackmans Bay, larva 23.xii.1981, em. 20.i.1982, R. Bashford (TFC).  
*Eucalyptus obliqua* L'Herit.  
Bicheno, larva 22.vii.1982, em. 18.viii.1982, R. Bashford (TFC).  
Florentine Valley, em. 15.iv.1980, R. Bashford (TFC).  
*Callistemon viminalis* (Gaert.) G. Don (i)  
Devonport, 1976, P. Geier (ANIC).

7. *rudisana* (Walker, 1863) (*Sciaphila*)  
*indecretana* (Walker, 1863) (*Penthina*)  
*eucycla* (Turner, 1916) (*Capua*)  
Virtually ubiquitous in habitats below 600 m.  
Foodplants: Fabaceae: *Trifolium repens* L. (i), an introduced forage plant.  
Grove, larva 30.iv.1979, em. 21.v.1979, M.A. Williams.  
Fabaceae: *Medicago sativa* L. (i), an introduced forage plant.  
Hayes, larva 16.ii.1972, em. not dated, R.J. Hardy.  
Rosaceae: *Rubus ursinus* Cham. & Schlechtend. var. *loganobaccus* L.H. Bailey (i), an introduced horticultural plant.  
Grove, larva 22.ii.1953, em. 12.iii.1953, K.A. Pickett.  
Cannabaceae: *Humulus lupulus* L. (i), an introduced horticultural plant.  
NE coast, larva no date, em. 23.ii.1971.  
Larva described by Cordingley & Danthanararyana (1976); polyphagous on a wide range of herbaceous and woody plants and achieving minor pest status on some horticultural crops.

8. *xuthobapta* Turner, 1945. (*Acropolitis*) New record for Tasmania.  
Open eucalypt forest.  
Foodplant: Myrtaceae: *Eucalyptus camaldulensis* Dehn. (i)  
Blackmans Bay, em. 3.i.1984, R. Bashford (TFC).

*AUTHOMAEMA* Turner, 1916  
Eucalypt forests at low altitudes. Larval foodplants unknown.

1. *diemeniana* (Zeller, 1877) (*Conchylis*)  
Open eucalypt forest.

2. *pentacoma* (Lower, 1900) (*Anatropia*)  
Open eucalypt forest.

*COELOPTERA* Turner, 1945  
Rainforest and wet sclerophyll forest, especially damp ferny gullies.

1. *epiloma* (Lower, 1902) (*Capua*). New record for Tasmania.  
Notes: Adults active in xii, i.

*CRYPTOPTILA* Meyrick, 1881  
Three described species in eastern Australia.

1. *immersana* (Walker, 1863) (*Teras*). New record for Tasmania.  
Rainforest margins to wet eucalypt forest.  
Foodplant: Lamiaceae: *Prostanthera lasianthos* Labill. A tall luxuriant shrub of rainforest or wet eucalypt forest margins.  
Rosebery, larva 22.xii.1983, em 13.iii.1984, P.B. McQuillan.  
Mt Wellington, 550 m, larva 10.xii.1989, em. 1.iv.1990, P.B. McQuillan..  
Liliaceae: *Lapageria rosea* Ruiz. & Pav. (i) (Chilean bellflower).  
Launceston; larva iii.1991, em. 15.iv.1991, P.B. McQuillan.  
Notes: The distinctive larvae, illustrated by Common (1990), tie the terminal leaves of the spring flush, reaching the final instar in December and January. Larvae can be locally abundant, infesting at least 20% of available foliage on individual plants. This species, the so-called ivy leafroller, is known to be highly polyphagous on mainland Australia on both native and introduced hosts (Common 1990).  
Turner's (1928) Tasmanian record of *C. australana* (Lewin, 1805), which is oligophagous on Araliaceae and Icacinaceae (Powell & Common 1985), is almost certainly a misidentification for this species.

*EPIPHYAS* Turner, 1927

*AUSTROTORTRIX* Bradley, 1956  
Rainforest, wet and dry sclerophyll forest, forest-shrubland ecotones, alpine and lowland heathland, agricultural and urban habitats. At least 30 species in southern and eastern Australia. Common (1961) has clarified the limits of the genus, which is closely related to *Merophyas* and *Ericodesma*.

1. *ashworthana* (Newman, 1856) (*Tortrix*)  
*responsana* (Walker, 1863) (*Teras*)  
*secundana* (Walker, 1863) (*Pandemis*)  
Open eucalypt forest. 0–860 m.  
Foodplants: Mimosaceae: *Acacia dealbata* Link, a tree in open forest or at edges of tall wet forest.  
Mt Nelson, 200 m, larva ix.1986, em. 3.xi.1986, P.B. McQuillan.  
Devonport, larva 22.ix.1986, em 15.x.1986, L. Hill.  
Woodsdale, em. x.1980, H.J. Elliott (I.F.B. Common, pers. comm.)  
*Acacia mearnsii* De Wild.  
Retreat, em. x.1980, H.J. Elliott (I.F.B. Common, pers. comm.)  
At least two generations annually in Tasmania. Most commonly reared from bipinnate-leaved acacias, but recorded from phyllodinous *A. longifolia* (Andrews) Willd. in New South Wales (I.F.B. Common, pers. comm.)

2. *aulacana* (Meyrick, 1881) (*Tortrix*)  
*asthenopsis* (Lower, 1902) (*Tortrix*)  
Open forest, at altitudes 0–300 m.

3. *caryotis* (Meyrick, 1910) (*Tortrix*)  
Rainforest and wet eucalypt forest, especially at higher altitudes.  
Foodplants: Fagaceae: *Nothofagus cunninghamii* (Hook.) Oersted  
Mt Field National Park, 650 m, final instar larva 26.iv.1988, em 4.x.1988, P.B. McQuillan.  
Myrtaceae: *Eucalyptus regnans* F. Muell.  
Maydena, 27.i.1961, K.W. Cramer (ANIC).  
Notes: This is a montane-alpine species on the southeastern mainland of Australia where it is evidently a polyphagous species, being reared from *Bossiaea*, *Cassinia*, *Daviesia*, *Tasmannia*, *Epacris*, *Oxylobium*, *Parahebe*, *Pimelea*, *Pinus*, and *Polyscias* (ANIC; I.F.B. Common, pers. comm.).

4. *cerussata* (Meyrick, 1910) (*Tortrix*)  
Montane forest and wet eucalypt forest, above 400 m.  
Foodplant: Asteraceae: *Olearia phlogopappa* (Labill.) DC.

- Mt Wellington, 400–1000 m, larvae in October 1985, em. 22.xii.1985–16.i.1986, P.B. McQuillan.  
Notes: Also reared from this host, NSW, 8 km NNW of Jindabyne, 1000 m, 31.iii.1971, I.F.B. Common & E.D. Edwards (ANIC).
5. *cetrata* (Meyrick, 1910) (*Tortrix*)\*  
Open forest.
6. *dotatana* (Walker, 1863) (*Teras*)  
*tanyptera* (Meyrick, 1910) (*Tortrix*)  
Montane forest and wet eucalypt forest.  
Possibly associated with Mimosaceae: *Acacia melanoxylon* R.Br. according to Meyrick (1910).  
On mainland Australia reared from Fabaceae: *Daviesia* sp. (I.F.B. Common, pers. comm.).
7. *erysibodes* (Turner, 1916) (*Tortrix*)  
Open forest.  
Foodplant: Asteraceae: *Olearia ramulosa* [extralimital]  
[A.C.T. Mt Gingera 1700 m, 17.ii.1950, I.F.B. Common (ANIC)].
8. *eucyrta* Turner, 1927 (*Epiphyas*)\*  
*leuropa* (Turner, 1939) (*Tortrix*)  
Wet heaths at low altitudes. Common in habitats with *Melaleuca* shrubs.
9. *fabricata* (Meyrick, 1910) (*Tortrix*)  
Montane forest and wet eucalypt forest.
10. *flebilis* (Turner, 1939) (*Tortrix*)\*  
*eucocephala* (Turner, 1945) (*Tortrix*)  
Wet eucalypt and mixed forest.
11. *hemiphoena* (Turner, 1927) (*Tortrix*)\*  
Mixed wet forest.
12. *loxotoma* (Turner, 1927) (*Tortrix*)\*  
Wet eucalypt forest.
13. *lycodes* (Meyrick, 1910) (*Tortrix*)\*  
Open subalpine forest.
14. *oresigona* (Turner, 1939) (*Tortrix*)\*  
Alpine heathland. 1200m.  
Foodplant: Asteraceae: *Helichrysum ledifolium* (DC.) Benth., a low aromatic shrub in alpine heathland.  
Mt Wellington, 1200 m, larvae 1.xii.1986, em 16–30.i.1987, P.B. McQuillan.  
Notes: Univoltine. Similar larvae were taken from *Helichrysum hookeri* (Sonder) Druce near Breona on the Central Plateau but were not reared.
15. *plastica* (Meyrick, 1910) (*Tortrix*)\*  
Margins of wet forests at middle altitudes.  
Foodplant: Asteraceae: *Cassinia aculeata* (Labill.) R.Br.  
Woodsdale, larva 20.viii.1981, em. 11.ix.1981, R. Bashford (TFC).
16. *postvittana* (Walker, 1863) (*Teras*)  
*basialbana* (Walker, 1863) (*Teras*)  
*consociana* (Walker, 1863) (*Pandemis*)  
*foedana* (Walker, 1863) (*Dichelia*)  
*oenopa* (Meyrick, 1910) (*Tortrix*)  
*phaeosticha* (Turner, 1939) (*Tortrix*)  
*retractana* (Walker, 1863) (*Dichelia*)  
*reversana* (Walker, 1863) (*Dichelia*)  
*citulana* (Walker, 1863) (*Teras*)  
*secretana* (Walker, 1863) (*Teras*)  
*stipularis* (Meyrick, 1910) (*Tortrix*)  
*vicariana* (Walker, 1869) (*Dichelia*)  
Virtually ubiquitous in habitats below 750 m. Multivoltine.
- Foodplants (native):  
Myrtaceae: *Eucalyptus obliqua* L'Herit.  
Hobart (glasshouse), larvae 20.iii.1984, em. 26.iii.–17.iv.1984, R. Bashford (TFC).  
*Eucalyptus pauciflora* Sieber ex Sprengel  
Perth nursery, larva 2.x.1981, em. 26.x.1981, R. Bashford (TFC).  
Foodplants (introduced):  
Brassicaceae: *Brassica oleracea* L. var. *gemmifera*. (i).  
Moriarty, larva 17.v.1976, em. no date, P.E.L. Rapley.  
Ericaceae: *Vaccinium corymbosum* L. (i).  
Lymington, larva 11.ii.1987, em. no date, M.A. Williams.  
Fabaceae: *Trifolium repens* L. (i).  
New Town, larva no date, em. 26.viii.1957, L.W. Miller.  
Geraniaceae: *Pelargonium* sp. (i).  
Burnie, larva 24.i.1958, em. 10.ii.1958, K.A. Pickett.  
Lamiaceae: *Mentha x piperita* (i).  
Ouse, larva 27.xi.1978, M.A. Williams.  
Rosaceae: *Prunus armeniaca* L. (i).  
East Risdon, larva 24.i.1957, em. 5.iii.1957.  
Penna, larva 7.ii.1957, em. 13.iii.1957.  
Rosaceae: *Prunus domestica* L. (i).  
Lindisfarne, larva 6.iii.1974, A Terauds.  
Rosaceae: *Malus domestica* Borkh. (i).  
Grove, larvae 12.ii.1965, 6.ii.1979, L.W. Miller, M.A. Williams.  
Rutaceae: *Fortunella japonica* (Thunb.). (i).  
Hobart, larva 16.i.1980, em no date, M.A. Williams.  
Saxifragaceae: *Ribes nigrum* L. (i).  
New Norfolk, 21.xi.1974, R.J. Hardy.  
New Town, 21.x.1984, R.J. Hardy.  
Plenty, larva 19.vii.1974, M.A. Williams.  
Vitaceae: *Vitis vinifera* L. (i).  
Legana, larva 12.iii.1979, em. no date, L.A. Miller.
- Notes: This is the notorious light brown apple moth which has adapted to a vast range of mainly introduced foodplants. Aspects of its ecology are discussed by Geier & Springett (1976).  
Danthanarayana (1975) lists 73 plant species in 27 families as foodplants Australia-wide.
17. *xylodes* (Meyrick, 1910) (*Tortrix*)  
*eurystropha* (Turner, 1926) (*Tortrix*)  
*paraplesia* (Turner, 1914) (*Tortrix*)  
Virtually ubiquitous in habitats below 1100 m.  
Foodplants (native):  
Malvaceae: *Asterotrichion discolor* (Hook.) Melville.  
Mt Nelson, 100 m, larva 10.xii.1986, em. 14.ii.1987, P.B. McQuillan.  
Monimiaceae: *Atherosperma moschatum* Labill.  
Mt Field National Park, larva 26.xi.1988, em 28.i.1989, P.B. McQuillan.  
Arve Valley, larva 4.v.1983, em. 20.vi.1983, R. Bashford (TFC).  
Myrtaceae: *Eucalyptus gunnii* Hook. f.  
Hobart, em. x.1957 (I.F.B. Common, pers. comm.).  
*Eucalyptus regnans* F.Muell.  
Florentine Valley, larva 13.iii.1980, em. 9.i.1984, R. Bashford (TFC).  
Euphorbiaceae: *Beyeria viscosa* (Labill.) Miq.  
Mt Nelson, 100 m, larva 10.xii.1986, em. 30.i.1987, P.B. McQuillan.  
Asteraceae: *Olearia tasmanica* (Hook. f.) W.M. Curtis.  
5 km SW of Mt Arrowsmith, larva 8.xii.1986. P.B. McQuillan & M. Horak, em. 10.i.1987.  
Cunoniaceae: *Anodopetalum biglandulosum* A. Cunn. ex Hook. f.  
Franklin River at Lyell Highway. Larva 6.xii.1986. P.B. McQuillan & M. Horak, em. 17.i.1987.  
Eucryphiaceae: *Eucryphia lucida* (Labill.) Baill.  
Arve Valley, larvae 21.xii.1982, em. 7–14.ii.1983, R. Bashford (TFC).  
Fagaceae: *Nothofagus cunninghamii* (Hook.) Oersted.  
Mount Field National Park, 650 m, larva 1.xii.1982, em. 3.i.1983, P.B. McQuillan.

Fagaceae: *Nothofagus gunnii* (Hook. f.) Oersted.

Lake Fenton, 1080 m, larva 1.xii.1982, em. 7.i.1983, P.B. McQuillan.

Phyllocladaceae: *Phyllocladus aspleniifolius* (Labill.) Hook. f.

Pelion Hut 860 m, larva iii.1991, P.B. McQuillan & M. Horak.

Thymeliaceae: *Pimelea nivea* Labill.

Mount Nelson 200 m, larva 25.x.1986, em. 4.xii.1986, P.B. McQuillan.

Foodplants (introduced):

Caprifoliaceae: *Lonicera* sp. (i).

Rosny, larva 11.vii.1979, K.A. Pickett.

Fabaceae: *Sophora tetraptera* J.F. Mill. (i).

New Town, larva no date, em. 7.iii.1956, W.J. Newport.

Myrtaceae: *Eucalyptus camaldulensis* Dehn. (i).

Blackmans Bay, larva 12.i.1984, em. 26.ii.1984, R. Bashford (TFC).

Rosaceae: *Fragaria* x *anayasa* Duchesne. (i).

Summerleas, larva no date, em. 5.v.1950, K.A. Pickett.

Rutaceae: *Citrus* x *paradisi* Macfady. (i).

Howrah, larva 5.xi.1974, M.A. Williams.

*Pseudotsuga menziesii* (Mirb.) Franco. (i).

Bransholm, larva no date, em. 29.ix.1972, P.E.L. Rapley.

18. sp. n. *A.\** (genitalia slide T310 in ANIC)

Asteraceae: *Olearia argophylla* (Labill.) Benth.

Eaglehawk Neck, 22.ii.1949, J. Calaby (ANIC).

#### *ERICODESMA* Dugdale, 1971

Open forest to heathland. Multivoltine. Several species in southern Australia and New Zealand.

1. *concordana* (Meyrick, 1881) (*Tortrix*)

Open forest and heathland.

Foodplant: Dilleniaceae: *Hibbertia* according to Meyrick (1910).

2. *indigestana* (Meyrick, 1881) (*Tortrix*)

Heathland and open treeless habitats.

Foodplants: Dilleniaceae: *Hibbertia*.

Larvae in spun shoots and leaves (Meyrick 1910)

Asteraceae: *Arctotheca calendula* (L.) Levyns (i) [Victoria].

Larvae in rolled and webbed leaves (Cordingley & Danthanarayana 1976).

3. *liquidana* (Meyrick, 1881) (*Cacaecia*)

Open woodland and heathland.

Foodplant: Lamiaceae: *Lavandula stoechas* L. (i).

Golconda, larva no date, em. 5.iii.1970, A. Terauds.

Notes: Native foodplants unknown.

#### *ISOTENES* Meyrick, 1938

Rainforest margins to subalpine open mixed forest. Together with the Papuan *Zacorisca* Meyrick, this genus has been included in the tribe Zacoriscini Diakonoff but Common (1958) regarded the group as specialised members of the Archipini.

1. sp. n. *A.\** New record for Tasmania.

Foodplant: Eucryphiaceae: *Eucryphia lucida* (Labill.) Baill.

Scotts Peak Road, larva xii.1983, em. 10.ii.1984, P.B. McQuillan.

Notes: Larvae tie two leaves of the foodplant together and erode the adjacent epidermis. Adults of this undescribed species have also been collected in the vicinity of *Eucryphia milliganii* Hook. f. (Reservoir Lakes, near Mt La Perouse) in February. A mainland congener, the orange fruitborer *Isotenes miserana* (Walker, 1863), is highly polyphagous on arboreal hosts and can be a pest of horticultural crops.

#### *MEROPHYAS* Common, 1963

Open habitats. Adults occur amongst low-growing herbaceous plants and their larvae feed upon annual and perennial dicotyledonous herbs. In addition to the five species listed here, at least two undescribed species occur in Tasmania. Alpine species on mainland

Australia feed upon low herbaceous plants, including *Celmisia*, *Craspedia*, *Brachycome* and *Ranunculus* (ANIC records).

1. *calculata* (Meyrick, 1910) (*Tortrix*)

Open woodland.

2. *divulsana* (Walker, 1863) (*Conchylis*)

*glaphyrana* (Meyrick, 1881) (*Tortrix*)

*cavillata* (Meyrick, 1922) (*Tortrix*)

*australiana* (Strand, 1924) (*Bactra*)

*cnecochyta* (Turner, 1945) (*Tortrix*)

*ischnosema* (Turner, 1945) (*Tortrix*)

Open habitats including coastal dune swales and pastoral land.

Foodplant: Onagraceae: *Epilobium billardierianum* Ser. ex DC.

Marion Bay, larva 13.xii.1986, P.B. McQuillan & M. Horak.

Fabaceae: *Medicago sativa* L. (i), an introduced perennial pastoral legume.

Brighton, larva 27.x.1986, em. 19.xi.1986, P.B. McQuillan.

Plantaginaceae: *Plantago* sp. (i), an introduced weedy annual.

Cambridge, larva 24.i.1985, em. 18.ii.1985, R. Bashford (TFC).

Notes: Larvae polyphagous. On mainland Australia, Common (1963) recorded this species, the lucerne leafroller, from *Senecio*, *Taraxacum*, *Lactuca*, *Antirrhinum*, *Gypsophila*, *Mentha* and *Bassia*. Cordingley & Danthanarayana (1976) reared examples from capeweed, *Arctotheca calendula* (L.) Levyns in Victoria. Larvae tie terminal leaves from October to April.

3. *immersana* (Walker, 1863) (*Paedisca*)

*argillosana* (Meyrick, 1881) (*Dichelia*)

*trygodana* (Meyrick, 1881) (*Tortrix*)

Open habitats, including pastures.

Foodplants: Fabaceae: *Trifolium repens* L. (i), an introduced pastoral legume and widespread weed [Victoria, Mornington Peninsula (ANIC)].

*Trifolium* sp. (i)

Sheffield, 1976, P. Geier (I.F.B. Common, pers. comm.)

*Lupinus* sp. (i)

Somerset, 1976, P. Geier (ANIC)

Malvaceae: *Malva* sp. (i)

Somerset, 1976, P. Geier (ANIC)

4. *tenuifascia* (Turner, 1927) (*Tortrix*)\*

Montane open forest.

5. *therina* (Meyrick, 1910) (*Epichorista*)

*microstictis* (Meyrick, 1910) (*Epichorista*)

Wet eucalypt forest to open montane forest.

Notes: On mainland Australia reared from Rosaceae: *Acaena anserinifolia* in the southeastern highlands (I.F.B. Common, pers. comm.).

#### *PHRYCTORA* species group

Sclerophyll forest. Larval foodplants unknown.

1. *cosmopsis* Lower, 1894 (*Dichelia*)

Dry eucalypt forest.

#### *PLACOXANTHA* species group

Rainforest to wet eucalypt forest. Known larvae on ferns.

1. *placoxantha* (Lower, 1896) (*Anisogona*)

Rainforest, mixed forest and wet eucalypt forest.

Foodplant: Aspidiaceae: *Polystichum proliferum* (R. Br.) Presl., an abundant low-growing fern along creek margins, seepages on forested hillsides, etc.

Mt Field National Park, larva xi.1989, em. 21.xii.1989, P.B. McQuillan.

2 km SW of Renison Bell, pupa 12.xii.1987, em. 18.xii.1987, P.B. McQuillan.

Notes: Eggs and oviposition behaviour described by Powell & Common (1985).

2. *effulgens* Meyrick, 1910 (*Capua*)\*  
Rainforest in western Tasmania.

*SOBRIANA* species group  
Forested habitats.

1. *alysidina* Turner, 1927 (*Tortrix*)\*  
Tall wet eucalypt forest.

2. *arcaria* Meyrick, 1910 (*Tortrix*)  
Rainforest margins, mixed forest.  
Foodplant: Winteraceae: *Tasmannia lanceolata* (Poir.) A.C. Smith.  
A common low to tall shrub of wet forests.  
Hartz Mountains, larvae 12.xi.1988, em 11.i.1989, P.B. McQuillan.  
Quamby Bluff, larvae common in December 1988, not reared.  
Notes: Larvae tie terminal leaves and flower clusters with copious silk. Locally very common and a majority of leaves can be tied on some plants.

3. *dyschroa* Turner, 1927 (*Tortrix*)\*  
Open alpine woodland.  
Foodplant: Taxodiaceae: *Athrotaxis cupressoides* D. Don.  
Pine Lake, 1200 m, larvae 2.xii.1984, em 12.i.1985, P.B. McQuillan.  
Notes: Larvae bore in tips of branchlets and pupate within.

4. *incompta* Turner, 1927 (*Tortrix*)\*  
*astathmeta* Turner, 1927 (*Tortrix*)  
Rainforest and mixed forest.  
Foodplant: Fagaceae: *Nothofagus cunninghamii* (Hook.) Oersted.  
A dominant shrub to tall tree in rainforest to low alpine forest.  
Mt Field National Park, larvae 2.xi.1986, em. 2–21.i.1987, P.B. McQuillan.  
Hartz Mountains National Park, larvae 6.xii.1988, em. 26.i.9.ii.1989, P.B. McQuillan.  
Note: Larvae tie 4–8 leaves of the spring flush in November to February. Like the previous members of the “*sobriana* group” this species is monophagous on elements of the palaeo-austral flora. This is a plesiomorphic species with affinities to *Williella* in New Caledonia (Horak 1984).

5. *ophiodesma* Lower, 1902 (*Cacaecia*)\*  
Subalpine open forest to montane forest.

6. *sobriana* Walker, 1863 (*Dichelia*)  
Wet eucalypt forest.

*STANDISHANA* species group  
Open sclerophyll forest to heathland. Larval foodplants unknown.

1. *concolorana* Meyrick, 1881 (*Tortrix*)  
Wet and dry open heath.

*TECHNITIS* species group  
Open forest to heathland; sea level to alpine but mostly montane; all endemic. Known larvae monophagous on shrubby Asteraceae (*Olearia*, *Helichrysum*), but one mainland species, *desmotana* Meyrick, 1881, on Myrtaceae: *Baeckea*, *Leptospermum* (ANIC records) and another, *amoenana* Walker, on spun shoots of Epacridaceae: *Monotoca* (Meyrick 1910).

1. *campylosticha* Turner, 1939 (*Tortrix*)\*  
Montane heathland to open woodland, especially where *Cyathodes* grows.  
Foodplant: Probably Epacridaceae.

2. *hydractis* Meyrick, 1910 (*Tortrix*)  
Montane forest.  
Notes: Reared from Asteraceae: *Olearia* spp. in the south eastern highlands of mainland Australia (I.F.B. Common, pers. comm.)

3. *polyphrica* Turner, 1927 (*Tortrix*)\*  
Subalpine.

4. *technica* Turner, 1939 (*Tortrix*)\*  
Foodplant: Asteraceae: *Helichrysum thyrsoideum* (DC.) Morris & J.H. Willis.  
Mt King William I, 800 m, larva 8.xii.1986, em. 2.i.1987, P.B. McQuillan & M. Horak.  
Notes: This foodplant also serves the closely related “*Tortrix*” *oriarcha* Meyrick in the subalpine areas of the Snowy Mountains (Powell & Common 1985).

5. *telephanta* Meyrick, 1910 (*Tortrix*)\*  
Subalpine open forest.

UNASSIGNED to species group within Archipini

1. *adoxodes* Turner, 1939 (*Tortrix*)\*  
Rainforest and mixed forest at altitudes 200–1000 m.  
Foodplant: Fagaceae: *Nothofagus cunninghamii* (Hook.) Oersted  
Mt Field National Park. Larvae 2.x.1985; em 14.xii.1985  
P.B. McQuillan.  
Hartz Mountains National Park. Larvae 16.x.1985; em. 22.xii.1985  
P.B. McQuillan.  
Notes: Larvae bore into the unextended leaf buds in spring, sometimes tying adjacent shoots together.

2. *antilecta* Turner, 1939 (*Tortrix*)

3. *campylosema* Turner, 1945 (*Tortrix*)\*  
Notes: Only known from the type specimen from Flinders Island.

4. *eucela* Meyrick, 1910 (*Tortrix*)\*  
Montane forest.

5. *haplopolia* Turner, 1939 (*Tortrix*)\*  
Wet eucalypt forest.

6. *humerellus* Walker, 1866 (*Crambus*). New record for Tasmania.  
*centurionana* Meyrick, 1881 (*Tortrix*)  
Eucalypt forest and coastal heathland.  
Foodplant: Possibly Fabaceae (I.F.B. Common, pers. comm.).  
Notes: Adults active in late winter.

7. *lathraea* Meyrick, 1910 (*Tortrix*)

8. *polymicta* Turner, 1927 (*Tortrix*)\*  
Wet forest.

9. *psapharana* Meyrick, 1882 (*Cacaecia*)\*  
Eucalypt forest.

10. *spodota* Meyrick, 1910 (*Tortrix*)  
Margins of montane eucalypt forest.

11. *stigmatias* Meyrick, 1910 (*Tortrix*)  
Wet eucalypt forest.

12. *tasmaniana* Walker, 1863 (*Conchylis*)  
Coastal heath.

## Tribe EPITYMBIINI

This tribe is largely developed in southern Australia (Common 1958), although extending to Papua. Its outstanding biological attribute is its dependence on leaf litter, especially that of *Eucalyptus*, as a food source (Common 1980).

About 26 formal and informal groupings of genus status are recognised (Common, unpublished) of which 16 occur in Tasmania.

*ANISOGONA* Meyrick, 1881  
Rainforest to wet sclerophyll forest or mesic situations in drier

forest. Six described species in eastern Australia. Larvae are unknown from field situations but leaf litter, including that of non-myrtaceous plants, is a probable food source.

1. *mediana* (Walker, 1863) (*Pandemis*)  
*acrothecta* Turner, 1927 (*Tortrix*)

Rainforest, mixed forest, wet eucalypt forest.

Notes: Eggs and oviposition pattern described by Powell & Common (1985).

#### ASTHENOPTYCHA Meyrick, 1881

##### ANATROPIA Meyrick, 1881

Wet and dry eucalypt forest. About 14 species inhabit eastern and southern Australia. Known larvae reared from *Eucalyptus* leaf litter (Powell & Common 1985).

1. *conjunctana* (Walker, 1863) (*Sciaphila*)

Wet and dry eucalypt forest.

2. *epiglypta* Meyrick, 1910 (*Asthenoptycha*)

Dry eucalypt forest.

#### CLARANA species group

Wet and dry sclerophyll habitats. Eight described species in southern and eastern Australia. No larvae are known from field collections.

1. *clarana* Meyrick, 1881 (*Dichelia*)

Eucalypt forests, gardens.

Notes: Eggs and oviposition pattern were described by Powell & Common (1985).

2. *hyperetana* Meyrick, 1881 (*Dichelia*)  
*crepusculana* Meyrick, 1881 (*Palaeobia*)  
*diphtheroides* Lower, 1902 (*Dichelia*)

Dry eucalypt forests.

Notes: Eggs and oviposition pattern were described by Powell & Common (1985).

3. *parastactis* Meyrick, 1910 (*Capua*)\*

Wet eucalypt forests.

#### CONSTRICATA species group

Wet and dry sclerophyll forests; urban gardens. About 14 species in southern and eastern Australia, including two in Tasmania.

1. *constrictana* Walker, 1866 (*Tortrix*)  
*montivagana* Meyrick, 1881 (*Dichelia*)

Eucalypt forests, suburban gardens.

Foodplant: Myrtaceae: *Eucalyptus* sp. Larvae reared on dead leaves (Powell & Common 1985).

Notes: Eggs and oviposition pattern described by Powell & Common (1985).

2. *ephedra* Meyrick, 1910 (*Capua*)\*

Eucalypt forest.

#### DEBILIANA species group

Dry sclerophyll forests. Three species in southeastern Australia. One member of this species group has been reared from *Eucalyptus* leaf litter.

1. *pentazona* Lower, 1901 (*Capua*)\*

Common in open eucalypt forest, 200–1080m.

Notes: Abundant in *Eucalyptus subcrenulata*–*E. coccifera* forest near Lake Fenton 1080 m in December.

#### EPITYMBIA Meyrick, 1881

Wet and dry sclerophyll forest to subalpine heathland. Nine species in southern New Guinea, eastern and southeastern Australia (Horak

& Common 1985). Known larvae appear to be associated with fallen leaf litter (Powell & Common 1985, Horak & Common 1985).

1. *alaudana* Meyrick, 1881 (*Epitymbia*)  
*periopa* (Meyrick, 1910) (*Capua*)  
*cydropis* (Turner, 1916) (*Capua*)

Eucalypt forests.

Foodplant: Myrtaceae. *Eucalyptus* sp. dead leaves adhering to fallen twigs and branches (Horak & Common 1985).

2. *isoscelana* (Meyrick, 1881) (*Dichelia*)  
*thetis* (Butler, 1882) (*Conchylis*)

Open forests to heathland, 0–1000m.

Foodplant: Myrtaceae; *Eucalyptus* sp.

Notes: Horak & Common (1985) reported the larva occupying a shelter formed between two adjacent dead eucalypt leaves attached to a fallen twig. In Tasmania, this species can be found in coastal heath and heathy moorland distant from eucalypts and must feed on litter from other plants as well.

3. *scotinopa* (Lower, 1902) (*Dichelia*)

Dry eucalypt forest.

#### EUPHONA species group

Wet and dry sclerophyll forests. Seven described species in western, southern and eastern Australia.

1. *euphona* Meyrick, 1910 (*Capua*)

Wet and dry eucalypt forest.

Foodplant: Myrtaceae: *Eucalyptus* leaf litter (Powell & Common 1985)

Notes: Eggs and oviposition characteristics described by Powell & Common (1985).

2. *oxygrammana* Meyrick, 1881 (*Acroceuthes*)  
*nimbosa* Turner, 1927 (*Capua*)

Eucalypt forest.

#### FUSCICEPSANA species group

Wet sclerophyll forest. One member of this species group has been reared on *Eucalyptus* leaf litter (Powell & Common 1985).

1. *cirrhoptera* Turner, 1927 (*Capua*)\*

Subalpine open forest.

#### ISOCHORISTA Meyrick, 1881

Wet and dry sclerophyll forest. About 12 species in southeastern Australia.

1. *chaodes* Meyrick, 1910 (*Isochorista*)

Tall wet eucalypt forest to open forest.

Foodplant: Myrtaceae: *Eucalyptus* sp.

Notes: Larvae skeletonise undersides of dead leaves (Powell & Common 1985).

2. *encotodes* Meyrick, 1910 (*Isochorista*)

Tall wet eucalypt forest.

3. *helota* Meyrick, 1910 (*Isochorista*)

Tall wet eucalypt forest.

4. *panaeolana* Meyrick, 1881 (*Isochorista*)

Wet eucalypt forest to open dry eucalypt forest.

Foodplant: Myrtaceae: *Eucalyptus* sp.

Notes: Larvae join dead leaves on the ground (I.F.B. Common, pers. comm.).

#### LEUCOSTACTA species group

Rainforest to wet sclerophyll forest.

1. *leucostacta* Meyrick, 1910 (*Capua*)

Larvae reared from *Eucalyptus* leaf litter (Powell & Common 1985). Eggs and oviposition pattern described by Powell & Common (1985).

This species may be a generalised archipine according to Horak (1984: 429).

*MERITASTIS* Meyrick, 1910

Sclerophyll forest at all altitudes. About 15 species in eastern and southern Australia. All known larvae feeding in leaf litter. Larvae of this genus may be quite mobile in the litter and are attracted to freshly fallen leaves (Common 1980).

1. *laganodes* (Meyrick, 1910) (*Tortrix*)

Wet eucalypt forest.

2. *lythrodana* (Meyrick, 1881) (*Cacoecia*)

Wet and dry eucalypt forest.

Foodplant: Myrtaceae: *Eucalyptus* sp., dead leaf litter (Powell & Common 1985).

Notes: Eggs and oviposition characteristics described by Powell & Common (1985).

3. *polygraphana* (Walker, 1863) (*Tortrix*)

Eucalypt forests.

4. *psarodes* (Meyrick, 1910) (*Tortrix*)

Open eucalypt forest at low altitudes.

Notes: Univoltine, with adults active in mid winter.

*RUPICOLANA* species group

Wet and dry sclerophyll forest. About 25 species in southeastern Australia.

Known larvae reared from *Eucalyptus* leaf litter (Powell & Common 1985).

1. *rupicolana* (Meyrick, 1881) (*Dipterina*)

Eucalypt forests.

2. *stereodes* (Meyrick, 1910) (*Cnephasia*)

Eucalypt forests.

*SPERCHIA* Walker, 1869

Forests, heathland, agricultural and urban situations; virtually ubiquitous. One species in southern and eastern Australia; probably introduced to New Zealand.

1. *intractana* Walker, 1869 (*Sperchia*)

*obfuscatana* (Meyrick, 1881) (*Capua*)

*sordidatana* (Meyrick, 1881) (*Capua*)

Ubiquitous at altitudes below 750m.

Foodplant: Myrtaceae: *Eucalyptus* sp. Larvae reared on leaf litter (Powell & Common 1985).

Notes: Eggs and oviposition pattern described by Powell & Common (1985).

*SUBFURCATANA* species group

Sclerophyll forests, heathland, lucerne paddocks. Two species in eastern Australia.

1. *schematica* Turner, 1927 (*Tortrix*)\*

Open forest.

2. *subfurcatana* Walker, 1863 (*Conchylis*)

Open forest, heathland, lucerne paddocks.

Notes: Larvae form a portable, usually tubular leaf-roll from which they feed and later pupate within (Powell & Common 1985). *Eucalyptus* leaves were accepted in captivity (Powell & Common 1985).

*TARACHOTA* species group1. *asemantica* Turner, 1927 (*Capua*)\*

*poliobaphes* Turner, 1927 (*Capua*)

Open forest.

2. *dryina* Meyrick, 1910 (*Capua*)3. *eugrapta* Turner, 1927 (*Capua*)\*

*thaleropis* Turner, 1927 (*Capua*)

4. *mersana* Walker, 1863 (*Teras*)

*chimerinana* Meyrick, 1881 (*Capua*)

*olana* Walker, 1863 (*Capua*)

Notes: Reared from dead *Eucalyptus* leaves on fallen twigs in New South Wales and Victoria (I.F.B. Common, pers. comm.)

*VACUANA* species group1. *vacuana* Walker, 1863 (*Conchylis*)

*mutatana* Walker, 1863 (*Grapholita*)

## UNASSIGNED TO SPECIES GROUP

1. *camacinana* Meyrick, 1882 (*Proselena*)\*

*concinula* Turner, 1927 (*Tortrix*)

Open eucalypt forest.

2. *catarrapha* Turner, 1945 (*Cnephasia*)\*

Open forest.

3. *contortula* Turner, 1927 (*Cnephasia*)\*

Open forest.

4. *crotala* Meyrick, 1910 (*Cnephasia*)\*

Wet eucalypt forest.

5. *euryphaea* Turner, 1939 (*Capua*)\*

Wet eucalypt forest.

6. *fractifascia* Turner, 1927 (*Cnephasia*)\*

Rainforest, mixed forest.

Foodplant: Dead leaves of Fagaceae: *Nothofagus cunninghamii* (Hook.) Oersted

Mt Field National Park, 800 m. Adult emerged from litter collected 12.ix.1985 P.B. McQuillan.

7. *gnophodryas* Lower, 1902 (*Dipterina*)\*

Rainforest, mixed forest, wet eucalypt forest.

8. *hyperacria* Turner, 1916 (*Epichorista*)9. *insignana* Meyrick, 1881 (*Pyrgotis*)

Eucalypt forest, coastal heathland.

Foodplant: Dead leaves of *Eucalyptus* (ANIC records).

10. *leptosticha* Turner, 1916 (*Epichorista*)11. *mermera* Meyrick, 1910 (*Cnephasia*)12. *multistriata* Turner, 1945 (*Capua*)\*13. *ochrobaphes* Turner, 1939 (*Capua*)\*14. *phosphora* Meyrick, 1910 (*Cnephasia*)\*

Alpine heathland.

Foodplant: Dead leaves under shrubs of Asteraceae: *Helichrysum ledifolium* (DC.) Benth.

Mt Wellington, 1240 m. Adult emerged from dead leaf mat sampled 30.x.1985. P.B. McQuillan.

15. *serena* Meyrick, 1910 (*Epichorista*)\*  
Mixed forest.

16. *smenodes* Meyrick, 1910 (*Epichorista*)\*  
Open forest.

## UNASSIGNED TO TRIBE

*ATELODORA* Meyrick, 1881  
A monobasic genus. Foodplant unknown.

1. *pelochytana* Meyrick, 1881 (*Atelodora*)  
Tall forest.

## Subfamily OLETHREUTINAE

Larvae mostly borers or gallformers in seeds, stems and roots, some leafrollers; relatively few species are polyphagous (Powell 1980). The majority of the 3000+ species are tropical in distribution. Of the four tribes recognised in Australia (Common 1990), two occur in Tasmania.

## Tribe EUCOSMINI

Larvae of numerous Australian Eucosmini are leafrollers on myrtaceous foliage.

*BATHROTOMA* Meyrick, 1881  
Two described species in eastern and southern Australia.

1. *constrictana* Meyrick, 1881 (*Bathrotoma*)  
Open forest to coastal and moorland heath.  
Foodplant: Myrtaceae: *Callistemon* and *Melaleuca* species.  
*Callistemon violaceus*. (i)  
Hobart; larvae 30.iv.1982; em. 7–15.vi.1982. R. Bashford (TFC).  
*Callistemon pallidus* (Bonpl.) DC.  
Fern Tree; larvae 12.iv.1991. P.B. McQuillan.  
*Callistemon* sp.  
Cambridge; larvae 8.iv.1982, em. 7–23.vii.1982, R. Bashford (TFC).  
Notes: Larvae live in a distinctive portable case constructed from several hollowed seed capsules stacked on each other.

*CROCIDOSEMA* Zeller, 1847

1. *plebejana* Zeller, 1847 (*Crocidosema*)  
Gardens, vacant weedy land, roadsides.  
Foodplants: Malvaceae: *Lavatera*, *Malva*, *Abutilon*, *Hibiscus*, according to Common (1990).  
Notes: Larvae feed in seed capsules. A cosmopolitan species, the cotton tipworm achieves minor pest status in cotton crops.

*HERMENIAS* Meyrick, 1911  
Sclerophyll forest. Probably associated with *Eucalyptus*.

1. *epidola* Meyrick, 1911 (*Hermenias*)  
Eucalypt forest.  
Adults active in June and July.

2. *imbrifera* Meyrick, 1911 (*Hermenias*)  
Eucalypt forest.

*NEOHERMENIAS* Diakonoff, 1966  
Rainforest.

1. sp. *A* (aff. *deloschema* Turner)\*  
Foodplant: Cunoniaceae: *Anodopetalum biglandulosum* (Hook.) Hook.  
Tyenna, em. 1–9.x.1990, P. Barker (TFC).  
Notes: Larvae boring in seed capsules, but leaving them to pupate between tied leaves (R. Bashford, pers. comm.).

*HOLOCOLA* Meyrick, 1881  
Open forest to alpine heathland.

1. *biscissana* Meyrick, 1881 (*Holocola*)  
Coastal heath.

2. *perspectana* (Walker, 1863) (*Grapholita*)  
Open forest; heathland.

3. *stilpna* (Turner, 1925) (*Acroclita*)\*  
Myrtaceous heathland, 0–1100 m.

4. *thalassinana* Meyrick, 1881 (*Holocola*)  
Heathland.  
Foodplant: Myrtaceae: *Leptospermum*, according to Meyrick (1911).

5. *triangulana* Meyrick, 1881 (*Holocola*)  
Open woodland; forest margins, 0–500 m.  
Foodplant: Mimosaceae: *Acacia* spp. (Meyrick 1881).  
Galls on *Acacia dealbata* Link.  
Black Hills, larva 2.viii.1974, M.A. Williams  
Cambridge, em. 23.xi.1978, R. Bashford (TFC)  
Ellendale, larva 16.vii.1974, M.A. Williams  
Mount Lloyd, larva 23.vii.1974, M.A. Williams  
Notes: Larvae excavate the woody uredineine fungal galls (*Uromycladium*) on *Acacia dealbata* Link. but also eat the webbed foliage. Ecological details of this species are given by New (1982).

*PALAEOBIA* Meyrick, 1881  
Open forest to heathland.

1. *fidana* Meyrick, 1881 (*Palaeobia*)  
Wet and dry heathland.

2. *longestriata* Durrant, 1891 (*Palaeobia*)  
Heathland, especially 500–1000m.

*STREPSICRATES* Meyrick, 1888

*STREPSICEROS* Meyrick, 1881  
Eucalypt forest to subalpine heathland. A large genus in southern Australia and New Zealand with larvae amongst spun shoots of Myrtaceae.

1. *argyrotypa* (Turner, 1927) (*Spilonota*)\*  
Subalpine heathland.

2. *chalcitis* (Meyrick, 1911) (*Spilonota*)\*  
Open forest.

3. *ejectana* (Walker, 1863) (*Sciaphila*)  
*igniferana* (Walker, 1863) (*Conchylis*)  
*saxana* (Walker, 1863) (*Sciaphila*)  
*servilisana* (Walker, 1863) (*Sciaphila*)  
Open eucalypt forest; coastal heath.  
Foodplants: Myrtaceae: *Eucalyptus amygdalina* Labill., especially young foliage.  
Hobart, larva 3.xii.1983, em. 9.i.1984, R. Bashford (TFC).  
Notes: Also reared from Myrtaceae: *Kunzea* and *Leptospermum* on mainland Australia (Meyrick 1911). Larvae amongst webbed-up shoots and leaves.

4. *euthytoma* Turner, 1946 (*Spilonota*)\*  
Wet coastal heath.

5. *honestia* (Meyrick, 1911) (*Spilonota*)  
Notes: Reared from Myrtaceae: *Leptospermum lanigerum* (Aiton) Smith in the Brindabella Range, ACT (I.F.B. Common, pers. comm.).

6. *hypomolybda* (Turner, 1927) (*Spilonota*)\*  
Subalpine open eucalypt forest.

Foodplant: Myrtaceae: *Eucalyptus coccifera* Hook. f.  
Pine Lake, Central Plateau, 1200 m, larva 28.viii.1984, em.  
23.x.1984, P.B. McQuillan.  
Notes: Larva in spun-up leaves.

7. *lucifera* (Turner, 1946) (*Spilonota*)\*  
Alpine heath.

8. *macropetana* (Meyrick, 1881) (*Strepsiceros*)  
Foodplant: Myrtaceae: *Eucalyptus*, according to Meyrick (1911).  
*Eucalyptus* sp.  
Hastings, em. ii.1949, J.H. Calaby (ANIC).  
Notes: Larvae feeding between joined leaves.

9. *morosa* (Meyrick, 1911) (*Spilonota*)  
Open forest.

10. *tarachodes* (Meyrick, 1911) (*Spilonota*)  
Subalpine heathland.

11. *tranquilla* (Meyrick, 1911) (*Spilonota*)  
Tall eucalypt forest.

12. *zopherana* (Meyrick, 1881) (*Strepsiceros*)  
Open forest.  
Notes: Reared from Myrtaceae: ?*Leptospermum* (hedge), South  
Perth, 1956 (I.F.B. Common, pers. comm.).

#### GENUS A

1. *chlidana* Turner, 1927 (*Epiphyas*)\*  
Wet forest.

#### Tribe GRAPHOLITINI

Larvae often feeding in or on seeds.

#### CYDIA Hubner [1825]

1. *pomonella* (Linnaeus, 1758) (*Phalaena*) (i)  
Gardens and orchards.  
Foodplant: Rosaceae: *Malus domestica* Bork. (apple) (i)  
Lindisfarne, larva 13.ii.1973, em 4.xii.1973, A. Terauds.  
This is the introduced codling moth.

2. *molesta* (Busck, 1916) (*Laspeyresia*) (i)  
This species, the oriental fruit moth, is regularly introduced to  
Tasmania in peaches grown on mainland Australia, but is not  
known to breed here.

3. *argyrocyrtia* Turner, 1939 (*Laspeyresia*)\*  
Coastal heathland.  
Foodplant: Fabaceae: *Glycine clandestina* J. Wendl.  
Rocky Cape National Park. Larvae 16.iii.1984, em. 22.x.1984  
P.B. McQuillan.  
Larvae live in the seed pods and consume the seeds.

#### Excluded species

The following species have been previously recorded for Tasmania,  
but should be deleted:

*Alytopistis tortricitella* (Walker)  
A member of the family Psychidae (M. Horak, pers. comm.).

*Anisogona similana* Walker  
A misidentification for *A. mediana* (Walker).

*Cryptoptila australana* (Lewin)  
A misidentification for *C. immersana* (Walker).

*Tortrix amoenana* Walker.  
Tasmanian populations have been differentiated as *T. campylosticha*  
Turner.

## DISCUSSION

Relative to many other invertebrate families, Tortricidae are well represented in the Tasmanian fauna and about one third of the taxa appear to be endemic. The intermittent geographical isolation of Tasmania and its special environments and plant communities such as cool-temperate rainforest and alpine heathland gave rise to a recognisably local element in the tortricid fauna which complements the more widespread Australian element found in the eucalypt forests and coastal heathlands of eastern Tasmania.

Rainforest habitats are characteristically colonised by members of the *sobriana* group along with *E. xyloides* as a polyphage, some litter feeders, one or two genera of fern feeders, a single "cnephasiine" and a single eucosmine. Gap-phase and forest-margin shrubs harbour monophages in the genera *Isotenes* and *Cryptoptila*.

Eucalypt forests are characterised by a high diversity of litter-feeding epitymbiines, *Epiphyas* and the olethreutine *Strepsicrates*.

Alpine heath has mostly endemic archipines such as *Epiphyas* and *Ericodesma*, while moorland heath is relatively rich in olethreutines associated with Myrtaceae.

The Tasmanian tortricid fauna is dominated by tortricines, which outnumber olethreutines sixfold. This contrasts with the situation in temperate parts of the northern hemisphere where olethreutines are dominant, but is similar to that reported for the New Zealand fauna (Dugdale 1971) and Australia generally (Common 1980) where tortricines also outnumber olethreutines. The relatively high proportion of tortricines may be partly due to the adaptation of many Australian tortricine genera to the xerophytic plant communities, especially to *Eucalyptus* (Common 1980). Also, unlike the Tortricinae, the large majority of Olethreutinae are derived from the Oriental fauna at a relatively recent date as reflected in their predominant presence in northern Australia (M. Horak, pers. comm.). The Australian Tortricinae are unique in respect of the Epitymbiini, mainly feeding on dead eucalypt foliage (Common 1980). However there is also evidence of considerable speciation of Archipini in alpine environments.

Tasmania is rich in primitive forms. There is indirect evidence that tortricines were pan-Gondwanic in the Cretaceous and remnants of this fauna are extant on Gondwana fragments in the southwest Pacific at least (Dugdale 1966, Horak 1984). Consistent with this hypothesis is the discovery of generalised endemic tortricines monophagous on elements of the palaeo-austral flora; '*Tortrix*' *incompta* on *Nothofagus cunninghamii*, '*T.*' *dyschroa* on *Athrotaxis cupressoides* and '*T.*' *arcaria* on Winteraceae. Nevertheless, the Tasmanian flora has simplified considerably since the Tertiary and been invaded by xerophytic taxa as the climate became drier. These generalised tortricines are likely to be the remnants of a more diverse fauna in the past.

The morphologically generalised *Arotrophora*-group associated with Proteaceae appear to have no close relatives on other continents, except for an outlier in India, and possibly coevolved with this plant family. The absence of this clade of moths from the South African fauna, if confirmed, may suggest a minimum date for the appearance of this hostplant relationship after the separation of the African landmass from Gondwana.

Several generalisations can be drawn from the patterns of foodplant utilisation as presently understood in the fauna. Asteraceae is a key family for Tasmanian tortricines, and

appears to have been an important arena for evolution in *Epiphyas* especially. These plants, particularly arborescent *Helichrysum* and *Olearia*, are diverse and prominent in a variety of open or semi-open habitats at all altitudes. Ecotones between open shrubland, eucalypt forest and rainforest are rich in species and some are pioneers into newly burned habitat. Others are longer lived and important components of alpine shrubland or forest margins. Asteraceae are also significant hosts of New Zealand archipines such as *Planotortrix* (Dugdale 1971). There, *Olearia* and its relatives support numerous species of leaf-mining Nepticulidae (Donner & Wilkinson 1989) although this is not the case in Tasmania.

Myrtaceae feature strongly as foodplants for Tasmanian olethreutines, which consist almost exclusively of Eucosmini. Common (1980) reported that only 7% of reared Australian olethreutines were restricted to *Eucalyptus* foliage and none feed upon dead leaves. However, Bassian Eucosmini in general appear to be reliant on this foodplant family. This is in marked contrast to the very low incidence of tortricines on living myrtaceous tissue, surprising given the high apparency of this host family in most habitats and the epitymbiine radiation based on myrtaceous leaf litter. Although competition by other insects for living eucalypt tissue can be intense this is unlikely to explain why so few tortricids exploit it. Rather, the biochemical defences may be too effective for Archipini to conquer, with the notable exception of *Acropolitis*. The few archipines found so far to develop on *Eucalyptus* are species with a tendency to polyphagy perhaps mediated by broad spectrum gut enzymes which effectively deal with a wide range of plants.

Ferns tend to have a limited but specialised phytophagous insect fauna and host several monophagous tortricids in Tasmania and New Zealand. However no tortricids in California or northwestern Europe use ferns.

There is a recognisable fauna of tortricines associated with the leaf litter of *Nothofagus* forests, as in similar forests in New Zealand (J.S. Dugdale, pers. comm.). Hence the litter-feeding habit, an austral phenomenon, is likely to predate the rise to dominance of the eucalypt forests. Whether or not the litter tortricines of the cool temperate rainforests are ancestral to the epitymbiine fauna of eucalypt forests remains unexplored.

Whereas coniferous trees are a major class of foodplants for numerous olethreutines in the northern hemisphere (Powell 1980), none are known from the Tasmanian gymnosperms (i.e. Phyllocladaceae, Podocarpaceae, Cupressaceae and Taxodiaceae). Only three Tasmanian tortricines utilise native conifers and one of these is highly polyphagous on angiosperms as well. There are also fewer conifer-feeding archipines in New Zealand than expected for the diverse gymnosperm flora (Dugdale 1977).

Other significant elements in the Tasmanian flora seem under-exploited by tortricids. No grasses are used as foodplants, in contrast to New Zealand where *Poa* and *Cortaderia* are utilised (Dugdale 1977), and Casuarinaceae, which otherwise have a rich and unusual moth fauna, support no tortricids in Tasmania. *Acacia* and Fabaceae also seem to support few species considering their abundance in lowland habitats.

Foodplant patterns may differ on a regional basis. It is noteworthy that two taxa recently recognised in the Tasmanian fauna (*Cryptoptila immersana* and *Isotenes* sp. A.) have mainland counterparts which are exceedingly polyphagous, yet here retain a restricted host range. On the

available data, a high proportion of the Tasmanian tortricids appear to be monophagous. This is similar to the situation in New Zealand reported by Dugdale (1977) but in contrast to the pattern observed in northwest Europe. In New Zealand the monophagy:polyphagy ratio is 47:20 but in Europe is 17:82. This could partly reflect more complete records for the northern hemisphere but the trend is probably reliable. Polyphagy in the Tasmanian tortricines is most marked in *E. xylodes* which attacks a wide range of trees and shrubs in rainforest, mixed forest and eucalypt forests. *E. postvittana* and *A. rudisana* have adapted to numerous introduced plants but take only a limited range of native hosts.

A high proportion of the endemic species in Tasmania occur in upland biotopes, reflecting the situation in New Zealand where over half the species and several genera are alpine. Their concealed feeding habits on or within their foodplant (e.g. in rootstocks) presumably allows them to escape the rigours of the climate (Dugdale 1971).

## ACKNOWLEDGEMENTS

I am grateful to the Australian Biological Resources Survey for financial assistance to complete this project. Mr L. Hill, Mr T. D. Semmens and Mrs M.A. Williams helped in field collections and the rearing of larvae. Mr R. Bashford (Tasmanian Forestry Commission) generously gave access to his rearing records. The Director, Department of Parks, Wildlife and Heritage, Hobart, granted permission to sample in National Parks. Dr I.F.B. Common (Toowoomba) and Dr M. Horak (CSIRO Entomology) kindly made available the results of their taxonomic studies on Tortricinae and Olethreutinae and made valuable improvements to my manuscript.

## REFERENCES

- BRADLEY, J.D., 1956: A new genus for *Tortrix postvittana* (Walker) and certain other Australian and New Zealand species (Lepidoptera: Tortricidae). *Bull. entomol. Res.* 47: 101–105.
- BUCHANAN, A.M., McGEARY-BROWN, A. & ORCHARD, A.E., 1989: *A CENSUS OF THE VASCULAR PLANTS OF TASMANIA*. *Tasm. Herb. Occ. Publ.* 2. Hobart: 82 pp.
- BUSCK, A., 1916: In Quaintance, A.L. & Wood, W.B. *Laspeyresia molesta*, an important new insect enemy of the peach. *J. Agric. Res., Dep. Agric. Washington D.C.* 7(8): 373–377.
- BUTLER, A.G., 1882: On a small collection of Lepidoptera from Melbourne. *Ann. Mag. Nat. Hist.* (5)9: 84–103.
- COMMON, I.F.B., 1958: The genera of the Australian Tortricidae (Lepidoptera). *Proc. 10th Int. Congr. Entomol.* 1: 289–295.
- COMMON, I.F.B., 1961: The generic position of the Australian light brown apple moth (Lepidoptera: Tortricidae). *Proc. Linn. Soc. NSW* 86: 177–182.
- COMMON, I.F.B., 1963: A new genus for the Australian lucerne leaf roller (Lepidoptera: Tortricidae). *Proc. Linn. Soc. NSW* 88: 298–300.
- COMMON, I.F.B., 1963: A revision of the Australian Cnephasiini (Lepidoptera: Tortricidae: Tortricinae). *Aust. J. Zool.* 11: 81–152.
- COMMON, I.F.B., 1965: A revision of the Australian Tortricini, Schoenotenini, and Chlidanotini (Lepidoptera: Tortricidae: Tortricinae). *Aust. J. Zool.* 13: 613–726.
- COMMON, I.F.B., 1980: Some factors responsible for imbalances in the Australian fauna of Lepidoptera. *J. Lepid. Soc.* 34: 286–294.

- COMMON, I.F.B., 1990: *MOTHS OF AUSTRALIA*. Melbourne University Press.
- CORDINGLEY, C.L. & DANTHANARAYANA, W., 1976: The lepidopterous fauna of capeweed (*Arctotheca calendula*) in Victoria with keys for larval identification. *J. Aust. Entomol. Soc.* 15: 19–34.
- DANTHANARAYANA, W., 1975: The bionomics, distribution and host range of the light brown apple moth, *Epiphyas postvittana* (Walk.) (Tortricidae). *Aust. J. Zool.* 23: 419–437.
- DONNER, H. & WILKINSON, C., 1989: Nepticulidae (Insecta: Lepidoptera). *Fauna NZ* 16.
- DUGDALE, J.S., 1966: A revision of New Zealand Schoenotenini and Cnephasiini (Lepidoptera: Tortricidae: Tortricinae). *NZ J. Sci.* 9: 731–775.
- DUGDALE, J.S., 1971: Entomology of the Aucklands and other islands south of New Zealand: Lepidoptera, excluding non-crambine Pyralidae. *Pac. Insects Mon.* 27: 55–172.
- DUGDALE, J.S., 1977: Some characteristics of phytophagous insects and their hosts in New Zealand. *NZ Entomol.* 6: 213–221.
- DURRANT, J.D., 1891: Description of a new species of Tortricidae. *Proc. Linn. Soc. NSW* (II) 6: 17–18.
- GEIER, P.W. & SPRINGETT, B.P., 1976: Population characteristics of Australian leafrollers (*Epiphyas* spp., Lepidoptera) infesting orchards. *Aust. J. Ecol.* 1: 129–144.
- HORAK, M., 1984: *Williella* — a new tortricine genus from New Caledonia indicating Gondwanan distribution for the family (Lepidoptera: Tortricidae). *Entomol. Scand.* 15: 423–433.
- HORAK, M. & BROWN, R.L., 1991: Taxonomy and phylogeny. in Van der Geest, L.P.S. & Evenhuis, H.H. (Eds): *TORTRICID PESTS, THEIR BIOLOGY, ENEMIES AND CONTROL*. Elsevier, Amsterdam.
- HORAK, M. & COMMON, I.F.B., 1985: A revision of the Australian genus *Epitymbia* Meyrick, with remarks on the *Epitymbiini* (Lepidoptera: Tortricidae). *Aust. J. Zool.* 33: 577–622.
- HORAK, M., WHITTLE, C.P., BELLAS, T.E. & RUMBO, E.R., 1988: Pheromone gland components of some Australian tortricids in relation to their taxonomy. *J. Chem. Ecol.* 14: 1163–1175.
- HUBNER, J., 1825: Verzeichniss bekannter Schmettlinge [sic]. Augsburg. *Signatures* 20–27: 305–431.
- LEWIN, J.W., 1805: *PRODROMUS ENTOMOLOGY. NATURAL HISTORY OF LEPIDOPTEROUS INSECTS OF NEW SOUTH WALES*. London. 18 plates.
- LINNAEUS, C., 1758: *SYSTEMA NATURAE*, 10. Holmiae, Laurentii Salvii: 824 pp.
- LOWER, O.B., 1894: New Australian Heterocera. *Trans. R. Soc. S. Aust.* 18: 77–113.
- LOWER, O.B., 1896: New Australian Lepidoptera. *Trans. R. Soc. S. Aust.* 20: 152–170.
- LOWER, O.B., 1900: Descriptions of new Australian Lepidoptera. *Proc. Linn. Soc. NSW* 25: 403–423.
- LOWER, O.B., 1901: Descriptions of new genera and species of Australian Lepidoptera. *Trans. R. Soc. S. Aust.* 25: 63–98.
- LOWER, O.B., 1902: Descriptions of new genera and species of Australian Lepidoptera. *Trans. R. Soc. S. Aust.* 26: 212–247.
- MEYRICK, E., 1881: Descriptions of Australian micro-Lepidoptera. V–VI. *Proc. Linn. Soc. NSW* 6: 410–536, 629–706.
- MEYRICK, E., 1882: Descriptions of Australian micro-Lepidoptera. *Proc. Linn. Soc. NSW* 7: 148–202.
- MEYRICK, E., 1887: Descriptions of new Lepidoptera. *Proc. Linn. Soc. NSW* [III] 1886: 1037–1048.
- MEYRICK, E., 1888: Notes on New Zealand Tortricina. *Trans. Proc. NZ Inst.* 20: 73–76.
- MEYRICK, E., 1910: Revision of Australian Tortricina. *Proc. Linn. Soc. NSW* 35: 139–294.
- MEYRICK, E., 1911: Revision of Australian Tortricina. *Proc. Linn. Soc. NSW* 36: 224–303.
- MEYRICK, E., 1922: *EXOTIC MICROLEPIDOPTERA*. Part 16: 481–512.
- MEYRICK, E., 1931: Papuan Microlepidoptera. *Trans. Roy. Entomol. Soc. Lond.* 87: 503–528.
- NEW, T.R., 1982: Lepidoptera from *Uromycladium* galls on *Acacia*. *Aust. J. Zool.* 30: 357–364.
- NEWMAN, E., 1856: Characters of a few Australian Lepidoptera, collected by Mr Thomas R. Oxley. *Trans. Entomol. Soc. Lond.* (n.s.) 3(8): 281–300.
- POWELL, J.A., 1980: Evolution of larval foodplant preferences in Microlepidoptera. *Ann. Rev. Entomol.* 25: 133–159.
- POWELL, J.A. & COMMON, I.F.B., 1985: Oviposition patterns and egg characteristics of Australian tortricine moths (Lepidoptera: Tortricidae). *Aust. J. Zool.* 33: 179–216.
- STRAND, E., 1924: Lepidoptera aus Sudwest-Australien. *Deutsche Entomol. Zeitschr., 'Iris'* 38: 135–148.
- TURNER, A.J., 1914: The Lepidoptera of Ebor Scrub, N.S.W. *Proc. Linn. Soc. NSW* 39: 546–564.
- TURNER, A.J., 1916: New Australian Lepidoptera of the family Tortricidae. *Trans. Roy. Soc. S. Aust.* 40: 498–536.
- TURNER, A.J., 1925: New Australian Lepidoptera. *Trans. R. Soc. S. Aust.* 49: 37–60.
- TURNER, A.J., 1926: Studies in Australian Lepidoptera. *Trans. R. Soc. S. Aust.* 50: 120–155.
- TURNER, A.J., 1927: New and little-known Tasmanian Lepidoptera. Part II. *Pap. Proc. R. Soc. Tasm.* 1926: 119–164.
- TURNER, A.J., 1928: A revision of the Lepidoptera of Tasmania. Part II. *Pap. Proc. R. Soc. Tasm.* 1927: 29–65.
- TURNER, A.J., 1939: A second revision of the Lepidoptera of Tasmania. *Pap. Proc. R. Soc. Tasm.* 1938: 57–115.
- TURNER, A.J., 1945: Contributions to our knowledge of the Australian Tortricidae (Lepidoptera). *Trans. R. Soc. S. Aust.* 69: 50–72.
- TURNER, A.J., 1946: Contributions to our knowledge of the Australian Tortricidae (Lepidoptera). *Trans. R. Soc. S. Aust.* 70: 189–220.
- WALKER, F., 1863: List of the specimens of lepidopterous insects in the collection of the British Museum, Part XXVII, Crambites and Tortricites. British Museum, London: 1–286.
- WALKER, F., 1865: List of the specimens of lepidopterous insects in the collection of the British Museum, Part XXXIV, Supplement, Part 4. British Museum, London: 1121–1533.
- WALKER, F., 1866: List of the specimens of lepidopterous insects in the collection of the British Museum, Part XXXV, Supplement, Part 5. British Museum, London: 1534–2040.
- WALKER, F., 1869: Characters of undescribed Lepidoptera Heterocera. London: 112 pp.
- ZELLER, P.C., 1847: Bemerkungen über die auf einer Reise nach Italien und Sicilien gesammelten Schmetterlingsarten. *Isis (Leipzig)* 1847: viii+561–549, xii+881–914.
- ZELLER, P.C., 1877: Exotische Microlepidoptera. *Horae Soc. Entomol. Ross.* 13: 3–493.

(accepted 1 May 1992)



## A REVISION OF THE TASMANIAN FRESHWATER CRAYFISH GENUS *ASTACOPSIS* HUXLEY (DECAPODA: PARASTACIDAE).

by Premek Hamr

(with three text-figures)

HAMR, P., 1992 (31:x): A revision of the Tasmanian freshwater crayfish genus *Astacopsis* Huxley (Decapoda: Parastacidae). *Pap. Proc. R. Soc. Tasm.* 126: 91–94. ISSN 0080-4703. 28 Undercliffe Ave, Hamilton, Ontario, L8P 3H1, Canada: formerly Department of Zoology, University of Tasmania.

During a broad study of the biology of the freshwater crayfishes in the Tasmanian genus *Astacopsis*, two distinct forms of *Astacopsis franklinii* were recognised. These “forms” were found to differ in terms of their general morphology and distribution. As a result, the taxonomy of *Astacopsis* has been revised to re-establish the three species originally described by Ellen Clark. *Astacopsis franklinii* Gray has been divided into two separate species, the eastern *Astacopsis franklinii* and the western *Astacopsis tricornis*, while the status of *Astacopsis gouldi* remains unaltered.

**Key Words:** *Astacopsis*, Tasmania, distribution, taxonomy.

### INTRODUCTION

The members of the genus *Astacopsis*, which include the world's largest freshwater crayfish (and therefore invertebrate) species, are associated with riverine and lacustrine habitats throughout Tasmania (Swain *et al.* 1982). Taxonomically and ecologically their closest relatives are the crayfishes of the genera *Euastacus* and *Astacoides* (Hobbs 1987, 1988, Riek 1972). The genus was first erected by Huxley in 1878 but earlier accounts and descriptions of crayfish now placed in this genus are available (Gray 1845, Gould 1870). Perhaps the earliest representation of *Astacopsis* is a painting made in 1832 by the convict artist William Buelow Gould in his “Book of Fishes”. The pictured crayfish is clearly identifiable as the large western form of *A. franklinii*, probably from the lower reaches of the Gordon River.

The existence of several Tasmanian varieties of crayfishes within the genus was recognised by Smith (1909, 1912) but he retained a single specific name, *A. franklinii*, for all Tasmanian members of the genus. Clark (1936) separated the Australian and Tasmanian members of the genus, assigning the former to a new genus *Euastacus* while reserving *Astacopsis* for the latter. At the same time, she revised *Astacopsis* adding two new species: *A. gouldi* (from northern Tasmania) and *A. tricornis* (from the Lake St Clair region). *A. franklinii* was retained and used for the smaller *Astacopsis* from the Launceston and Hobart regions. Riek (1969) added another species, separating *A. franklinii* into *A. fluviatilis* (from southern Tasmania) and *A. franklinii* (from northern Tasmania). Swain *et al.* (1982) revised the genus and reduced the number of species from four to two by including *A. fluviatilis* and *A. tricornis* within *A. franklinii*.

*A. gouldi*, the giant freshwater crayfish or “lobster”, as it is called locally, is the world's largest known crayfish, attaining weights of more than three kilograms (Smith 1909, Lynch 1967, Hobbs 1988). The species is restricted to the north of Tasmania, where it can be found in streams, rivers and reservoirs draining into the Bass Strait, as well as in the Arthur River system in the extreme northwest (Swain *et al.* 1982).

*A. franklinii* is found throughout most of Tasmania (Swain *et al.* 1982) in, or in association with streams, rivers and lakes. Although generally smaller than *A. gouldi*, it appears

to vary greatly in size and spininess. In their re-examination of the various morphological characters, Swain *et al.* (1982) found that the variation in spininess and size had a geographical basis. It will be shown in this study that this variation is, in fact, at least partly due to the occurrence of two distinct forms within *A. franklinii*, and it is further proposed that these two forms should be treated as two separate species.

### METHODS

The specimens used in the diagnosis of the species of *Astacopsis* were collected during a broad study of population structure and reproductive biology of the crayfishes in this genus (Hamr 1990). The morphometric descriptions and measurements were obtained from individuals collected at various sites throughout Tasmania between 1985 and 1989. Individuals from numerous populations throughout the range of each species were examined and compared.

Crayfish were captured using baited nets and hand lines, as well as by hand, using snorkelling equipment and turning over rocks and submerged logs.

Morphometric measurements for all specimens used in this revision were measured with Vernier callipers and recorded to the nearest tenth of a millimetre, including carapace length (CPL = rostrum tip to back edge of carapace) which was used as a standard measure. Rostral width (RW) refers to the maximum width of the rostrum between the eyes. The inter-ocular width was chosen as it was least affected by growth-related changes in the morphology of the rostrum. The mean-size adjusted inter-ocular rostral width refers to the ratio between rostral width and carapace length (RW/CPL). Populations of *A. franklinii* from Hobart Rivulet and the Lake St Clair region (Clarence Lagoon) were used in the rostral morphometry comparisons because they correspond to the original *Astacopsis* species described by Ellen Clark (1936).

Some of the specimens examined, as well as new distributional information, were obtained from Dr A.M.M. Richardson's taxonomic collection at the University of Tasmania, as well as from surveys conducted by the Inland Fisheries Commission (Tasmania).

## RESULTS AND DISCUSSION

During the examination of Tasmanian populations of *Astacopsis franklinii*, two distinct forms were recognised. These forms appear to have non-overlapping distributions (fig. 1) and were found to differ in terms of their general morphology as well as their size at maturity (Hamr 1990). Because of these differences, these forms are here referred to as two species.

The most reliable morphological characters separating the species of *Astacopsis* were found on the rostrum. *A. gouldi* can be clearly distinguished from the other two species by the presence of a median rostral carina, while *A. franklinii* can be separated from *A. tricornis* on the basis of rostral width and depth (fig. 2) Figure 3A & B shows the difference in the inter-ocular rostrum width between the species. In addition, the mean-size adjusted inter-ocular rostral widths of *A. tricornis* (mean = 0.126, s.d. = 0.013, n = 35) and *A. franklinii* (mean = 0.11, s.d. = 0.006, n = 51) were found to be significantly different ( $t = -7.92$ ,  $df = 84$ ,  $p < 0.0001$ ).

Although some differences in rostral morphology were noted by previous authors (Riek 1936, Swain *et al.* 1982), no characters other than the presence or absence of the median rostral carina and the morphology of spines on the lateral carinae were examined.

As shown by Swain *et al.* (1982), the exact number and location of spines are clearly unreliable taxonomic characters for separating *Astacopsis* species. There is, however, a clear difference in overall spininess between *A. franklinii* and *A. tricornis*, especially in adult individuals. This difference was shown by Swain *et al.* (1982) who stated: "Examination of the material in our collection suggested that much of the variation in general spininess of *A. franklinii* had a geographical basis, with a reduction in spininess both from west to east and north to south". Similarly they found that "large animals were present only in collections from river systems draining north or west". This corresponds directly with the distribution of the two species previously grouped under *A. franklinii* as identified in this study (fig. 1). Their failure to detect the clear east-west separation was probably due to sampling discrepancies (such as low numbers of crayfish from the northeastern region) and the large size/age range of animals in their samples. As it is generally more difficult to recognise the specific characters in juveniles of closely related crayfish species, the best results in keying out members of the genus *Astacopsis* are obtained when adults are compared.

The findings of this study suggest that the two previously recognised forms of *A. franklinii* can be treated as separate species. The "western form" description in this study corresponds closely to the initial description of *Astacopsis tricornis* by Clark (1936), who recognised differences between the southeastern and western populations of *A. franklinii*. Her sampling of the western form, however, was restricted to the Lake St Clair region and therefore, she failed to recognise the wider distribution of this species. Nevertheless, it is suggested that *A. tricornis* should be re-erected and assigned to the larger, western form of the present *A. franklinii*.

The differences between the two species arising from *A. franklinii* and the revised key for the genus *Astacopsis* are described as follows:

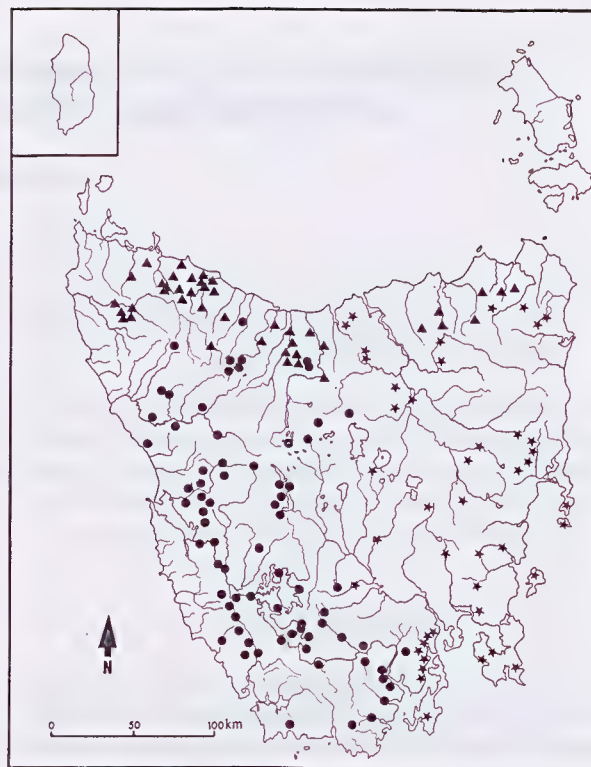


FIG. 1 — Distribution of *Astacopsis gouldi* (triangle), *Astacopsis franklinii* (star) and *Astacopsis tricornis* (circle) in Tasmania.

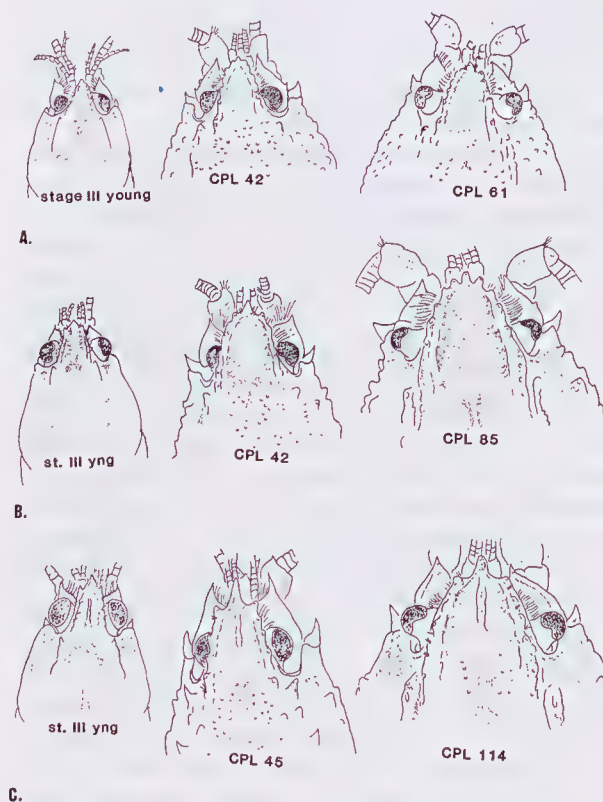


FIG. 2 — Comparison of rostral morphology (stage III young to large adult) in *Astacopsis franklinii* (A), *Astacopsis tricornis* (B) and *Astacopsis gouldi* (C). CPL = carapace length.

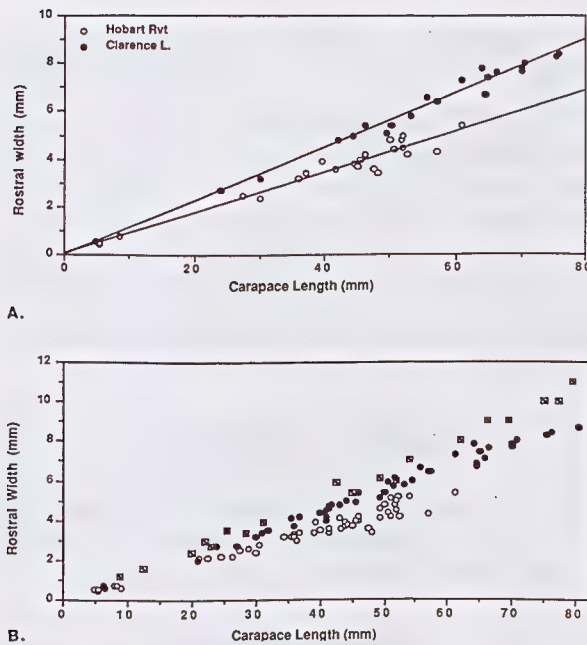


FIG. 3 — (A) The relationship between interocular rostral width and carapace length in *Astacopsis franklinii*, from Hobart Rivulet (open circle;  $y = 0.055 + 0.085x$ ,  $r^2 = 0.953$ ) and *Astacopsis tricornis*, from Clarence Lagoon (closed circle;  $y = 0.024 + 0.113x$ ,  $r^2 = 0.971$ ). (B) The relationship between interocular rostral width and carapace length in *Astacopsis franklinii* (open circle;  $y = 2.0379e-2 + 8.7363e-2x$ ,  $r^2 = 0.952$ ), *Astacopsis tricornis* (closed circle;  $y = 0.17927 + 0.10614x$ ,  $r^2 = 0.981$ ), and *Astacopsis gouldi* (open square with dot;  $y = -0.21848 + 0.13415x$ ,  $r^2 = 0.990$ ) in various Tasmanian populations.

## KEY TO THE GENUS *ASTACOPSIS*

- 1a. Rostrum divided by a median longitudinal carina ..... *A. gouldi* Clark.
- 1b. Rostrum without a median longitudinal carina ..... 2.
- 2a. Rostrum broad, concave, U-shaped. Adults large with numerous, prominent spines and tubercles ..... *A. tricornis* Clark.
- 2b. Rostrum narrower, flat, V-shaped. Adults small with less prominent spines and tubercles ..... *A. franklinii* Gray.

## SPECIES DESCRIPTIONS

### *Astacopsis franklinii*

*Astacus franklinii* Gray, 1845: 409.  
*Astacopsis tasmanicus* Smith, 1909: 65.  
*Astacopsis franklinii* v. *tasmanicus* Smith, 1912: 156.  
*Astacopsis franklinii* Clark, 1936:34; 1939:119; Riek, 1969: 898.  
*Astacopsis fluviatilis* Riek, 1969: 912.  
*Astacopsis franklinii* Swain *et al.*, 1982: 700.

### Diagnosis

Adults small (largest specimen: 61 mm CPL, 0.060 kg); Rostrum narrower anteriorly, V-shaped, shallow (flat), apex

terminated in single blunt spine; lateral rostral carinae blunt, with 6–7 low tubercles; small tubercle at base of carinae (fig. 2); eyes large; body armature relatively heavy, spines less sharp overall, tubercles on brachistegites small and uniform; great chelae short and stout with large palm and short fingers, covered with small depressions (on palm) and tubercles (on fingers); large spine on merus; held horizontally with respect to substrate; sternal keel blunt, lateral processes low, unsculptured, little tuberculation; male genital papilla with complete calcified tube, separated from basal portion of coxopodite in mature individuals; tube sculptured, less cylindrical; telson calcified, without transverse suture, with single spine on lateral margins; uropods calcified uniformly in immature individuals and adult males, decalcified distally in mature females; juveniles: basically light orange brown; adults: basically dark brown, tubercles orange, underside light orange brown; blue morphs are infrequently found among adults.

### Distribution

Eastern half of Tasmania, approximately east of a line from the Wellington Range in the south through the midlands to the Asbestos Range in the north (fig. 1). New locality records: Fortescue Bay, Lagoon Creek, Allens Creek (Tasman Peninsula); Guy Fawkes Rivulet; Appledorf Creek; Tyenna River; Captain Cook Creek tributary (Bruny Island), Falls Creek tributary (Bruny Island); Browns Creek (Asbestos Range N.P.); Swan Rivulet tributary; Crocketts Creek (Schouten Island); Eastern Rivulet, Jimmy Rivulet and Cooks Beach–Mt Graham track (Freycinet Peninsula).

### *Astacopsis tricornis*

*Astacopsis tricornis* Clark, 1936: 36; 1939: 120.  
*Astacopsis franklinii* Swain *et al.*, 1982: 700.

### Diagnosis

Adults medium to large (largest specimen: 148.4 mm CPL, 1.00 kg; rostrum broad, deep (concave), strongly U-shaped, apex terminated in several spines; lateral rostral carinae sharp, raised with 5–6 raised tubercles (fig. 2); eyes large; body armature heavy; spines on abdomen, chelae and walking legs, large and sharp in specimens of all sizes; prominent raised tubercles of variable size and sharpness, laterally on brachistegites and cephalic region; great chelae large, fingers long, covered with prominent tubercles/spines; prominent sharp spine on merus; palm without depressions; held horizontally with respect to substrate; sternal keel sharp, lateral processes raised, sculptured, tuberculate with winglike appearance in adults; male genital papilla with complete calcified tube, separated from basal portion of coxopodite in mature individuals; tube more cylindrical, less sculptured, with prominent raised keel; telson calcified, without transverse suture, with single spine on lateral margins; uropods calcified uniformly in immature individuals and adult males, decalcified distally in mature females; colour — juveniles: very light brown, sometimes grey; underside ivory; adults: basically brown to light brown; tubercles and spines yellow; those on brachistegites especially prominent; blue marking on brachistegites and cephalic region present in very large individuals; underside ivory; blue morphs not noted.

## Distribution

Western half of Tasmania, approximately from the Huon River in the south through the western edge of the Central Plateau to the Gog Range in the north (fig. 1). New locality records: Pigsty Ponds; Pelverata Falls; Arve River tributary; creek draining into Reservoir Lake; Meander River; Croanna Creek; Prince Rivulet; Weld River; Harlequin Hill (burrow in buttongrass plain); Sandfly Creek (Scotts Peak road); Scotts Peak (rainforest creek draining into Lake Pedder); Swampy Creek; Dozer Creek; two un-named creeks running into Bonnett Bay, Lake Pedder; Serpentine River (below dam); Melaleuca Creek (Melaleuca); Giblin River; Lake Meston; Clarence Lagoon; Lake Dixon; Lake Margaret; Ring River tributary (near Murchison Highway); Murchison River; Princess River; Comstock Creek; Heazlewood River tributary; Jean Brook; Eel Hole Creek.

## *Astacopsis gouldi* Clark

*Astacus* sp. Gould, 1870: 42.

*Astacopsis franklinii* Huxley, 1978: 764; Smith, 1909: 65; 1912: 154.

*Astacopsis gouldi* Clark, 1936: 35; 1939: 119; Riek, 1969: 898; Swain *et al.*, 1982: 701.

## Diagnosis

Adults very large (largest specimen: 214 mm CPL, 4.0 kg); rostrum broad, relatively shallow, V to U-shaped, apex sharp, terminated in single prominent spine, longitudinal carina in centre of rostrum (generally well-defined but can be weak on some small specimens), lateral rostral carinae raised with 3–6 blunt tubercles on each side, blunt spine at base of rostral carinae (fig. 2); eyes large; body armature heavy; spines and tubercles on chelae, walking legs, carapace and abdomen; cephalothoracic and abdominal spines much sharper in smaller specimens becoming blunter in large specimens (fig. 2); great chelae stout and very large, especially in adult males (adult female chelae less robust, thinner and more elongate), outer surface of both fingers covered with small, yellow tubercles/spines; prominent sharp spine on merus; held horizontally with respect to substrate; sternal keel moderately sharp, with a sharp, ventrally facing spine on process between second and third pereopods; male genital papilla with complete calcified tube, separated from basal portion of coxopodite in mature individuals; telson calcified, without transverse suture, with single spine on lateral margins; uropods calcified uniformly in immature individuals and adult males, decalcified distally in mature females; colour-juveniles: basically brown with green mottling, spines and tubercles white, underside of cephalothorax ivory; adults: basically dark brown-green, sometimes almost black, chelae brown with greenish tips, tubercles and spines yellow; characteristic blue marking laterally on brachioistegites and cephalic region; blue morphs are often found among adults, in these the basic overall colour is bright blue.

## Distribution

The known distribution of *A. gouldi* is shown in figure 1. New locality records: Pearly Brook (Horwitz, pers.comm.); St Patricks River (introduced population); Garden of Eden Creek; Gunns Plains Caves; Lake Barrington; West Gawler

River; Inglis River tributary (near Henrietta); Big Creek; Hellyer River; Detention River; Wilsons Creek; Sumac Rivulet.

In Gunns Plains caves, specimens ranging in carapace lengths from 55 mm to 147 mm were collected from the creek running through the cave as far as 300 m from the tourist entrance. From this study, as well as the observations of Mr Des Wing, the cave caretaker, it appears the crayfish live and breed inside the cave (Mr Wing reports seeing berried females as well as small juveniles deep within the cave). This constitutes the first report of such a phenomenon in Tasmania.

## ACKNOWLEDGMENTS

This study was supported by an internal research grant from the University of Tasmania. I thank all people who helped in the collection of crayfishes.

## REFERENCES

- CLARK, E., 1936: The freshwater and land crayfishes of Australia. *Mem. Nat. Mus. Vict.* 10: 5–58.
- CLARK, E., 1939: Tasmanian Parastacidae. *Pap. Proc. R. Soc. Tasm.* (1938): 117–128.
- GOULD, C., 1870: On the distribution and habits of the large freshwater crayfish (*Astacus* sp.) of the northern rivers of Tasmania. *Pap. Proc. R. Soc. Tasm.* 1870: 42–44.
- GOULD, W.B., 1932: *BOOK OF FISHES. A sketchbook containing 35 watercolours of fishes found at Macquarie Harbour (studies for Dr de Little)*. Allport Library and Museum of Fine Arts, State Library of Tasmania, Hobart, Tasmania.
- GRAY, J., 1845: Description of some new Australian animals. In Eyre, E.J. (Ed.): *Journals of Expeditions of Discovery into Central Australia and Overland from Adelaide to King George Sound, in the years 1840–41*. Vol 1: Appendix. T. and W. Boone, London: 407–11.
- HAMR, P., 1990: Comparative reproductive biology of the Tasmanian freshwater crayfishes *Astacopsis gouldi* (Clark), *Astacopsis franklinii* (Grey), and *Parastacoides tasmanicus* (Clark). Unpubl. PhD thesis, Zoology Department, University of Tasmania, Hobart.
- HOBBS, H.H., 1987: A review of the genus *Astacoides* (Decapoda: Parastacidae). *Smithson. Contrib. Zool.* 443: 1–50.
- HOBBS, H.H., 1988: Crayfish distribution, adaptive radiation and evolution. In Holdich, D.M. & Lowery, R.S. (Eds): *FRESHWATER CRAYFISH: BIOLOGY, MANAGEMENT AND EXPLOITATION*. Croom Helm, London: 52–82.
- LYNCH, D.D., 1967: *Synopsis of biological data of the giant freshwater crayfish Astacopsis gouldi Clark 1936*. Inland Fisheries Commission Publ., Tasmania.
- RIEK, E.F., 1969: The Australian freshwater crayfish (Crustacea: Decapoda: Parastacidae), with descriptions of new species. *Aust. J. Zool.* 17: 855–918.
- RIEK, E.F., 1972: The phylogeny of the Parastacidae (Crustacea: Astacoidea), and description of a new genus of Australian freshwater crayfishes. *Aust. J. Zool.* 20: 369–389.
- SMITH, G., 1909: The freshwater Crustacea of Tasmania. *Trans. Linn. Soc. London* (Ser. 2) 11: 61–92.
- SMITH, G., 1912: The freshwater crayfishes of Australia. *Proc. Zool. Soc.* 10: 144–171.
- SWAIN, R., RICHARDSON, A.M.M. AND HORTLE, M., 1982: Revision of the Tasmanian genus of freshwater crayfish *Astacopsis* Huxley (Decapoda: Parastacidae). *Aust. J. Mar. Freshw. Res.* 33: 699–709.

(accepted 1 May 1992)

## THE LASER RAMAN IDENTITY OF GIBBSITE PSEUDOMORPHOUS AFTER CROCOITE FROM DUNDAS, TASMANIA

by K. A. Rodgers

(with three text-figures and three plates)

RODGERS, K. A., 1992 (31:x): The laser Raman identity of gibbsite pseudomorphous after crocoite from Dundas, Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 95–99. ISSN 0080–4703. Department of Geology, University of Auckland, Private Bag, Auckland, New Zealand.

Gibbsite both invests and replaces crocoite in late supergene ores of the Dundas district, Tasmania. The laser Raman spectrum of the gibbsite shows strong, well-developed v-OH stretching bands at about 3370, 3440, 3525, 3620  $\text{cm}^{-1}$ , confirming its identity. Crocoite gives bands at 840  $\text{cm}^{-1}$   $\nu_1$ , 853 and 825  $\text{cm}^{-1}$   $\nu_3$ , 348  $\text{cm}^{-1}$   $\nu_2$ , 400, 377, 358, 338 and 326  $\text{cm}^{-1}$   $\nu_4$ , and at 179, 135, and 118  $\text{cm}^{-1}$ , corresponding to crystal field components of Pb–O vibrations and lattice modes. The chemistry of the late, mineralising fluids is unknown and the relative stabilities of crocoite and gibbsite can not be determined.

**Key Words:** gibbsite, crocoite, Raman spectra, Dundas, Tasmania.

### INTRODUCTION

Crocoite ( $\text{PbCrO}_4$ ) was first described from silver–lead mines of the Dundas district of Tasmania by Petterd (1894). Subsequently, numerous spectacular specimens, not equalled in quality elsewhere, have been collected from the region (e.g. Palache 1896, Petterd 1902, Anderson 1906, Lancaster 1977, Bancroft 1984, Haupt 1988).

The mineral commonly occurs as radiating masses of adamantine to vitreous, vermilion, prismatic crystals, lining vugs and coating fractures in the wall rock and gossan, and frequently intermixed with friable clays. Reported associated minerals include so-called “chromian” cerussite, massicot, chalcophanite, and rarer pyromorphite and dundasite, as well as “limonite” and “wad”. Often the prismatic crystals are hollow.

Gibbsite is also abundant in the Dundas mines, “where it encrusts gossan and often coats crocoite crystals” (*Catalogue of the minerals of Tasmania* 1970: 49; Lancaster 1977, Haupt 1988). In crocoite specimens from Dundas in the collection of the Australian Museum, gibbsite not only invests crocoite but also pseudomorphs the hollow prisms, a relationship not previously described. The identity of gibbsite in both habits is confirmed by non-destructive laser Raman microsampling procedures and the textural relationships are clarified by electron microscopy.

gossan, coated with “wad” and sparse pyromorphite(?), and heavily encrusted with radiating, acicular, hollow prisms of crocoite, partly pseudomorphed by gibbsite. The prismatic crystals range from 1–25 mm long and 0.1–4 mm across, with dull scarlet to vermilion bases grading through patchy, pale vermilion to pale orange-yellow crystal walls, to off-white terminations (pl. 2). The prisms are hollow throughout much of their upper extent, and here they have been more or less replaced with gibbsite, including terminations, most of which are missing or damaged (pls 2, 3A,B). Crystals walls are typically c. 0.05–0.2 mm thick, irrespective of the mineralogy. Near their attachment, the crystals are solid but with hollow cores, the inner surfaces of which are also lined by gibbsite (pl. 3C). Throughout all the crystal mass, the surface lustre of the crocoite has been dulled with a dusting of gibbsite. The pale, pseudomorphed portion consists of a mosaic of 10–50  $\mu\text{m}$  diameter, transparent, vitreous gibbsite crystallites (pl. 3D). Replacement renders the hollow crystal walls more translucent and the mosaic structure can be clearly seen in transmitted light, mottled with and outlined in pale orange-yellow. The extent of staining varies, with some close-packed crystallites, forming the upper pseudomorph wall, being pellucid, with only a hint of yellow tinting the crystal mass.

### RAMAN SPECTROSCOPY

#### Gibbsite

Gibbsite was confirmed using laser Raman spectroscopy, employing instrumental conditions given in Cooney *et al.* (1989) and Rodgers *et al.* (1989). The Raman spectra of fragments of the white encrustations and of different areas of the crystal walls were recorded by microsampling, using a Jobin-Yvon U1000 instrument with 514.5 nm  $\text{Ar}^+$  as the exciting line. Laser power was 1 W with 100 mW recorded at the sampling lens (an uncoated  $\times 40$  objective of a Nikon microscope). Monochannel Ga–As photomultiplier detectors were employed. Spectra for gibbsite were recorded from 3000–3700  $\text{cm}^{-1}$  and 100–1300  $\text{cm}^{-1}$ .

Initial determinations were made of a white, 3 mm diameter ball investing a small group of crocoite crystals in specimen D42734. A small portion of the ball was crushed,

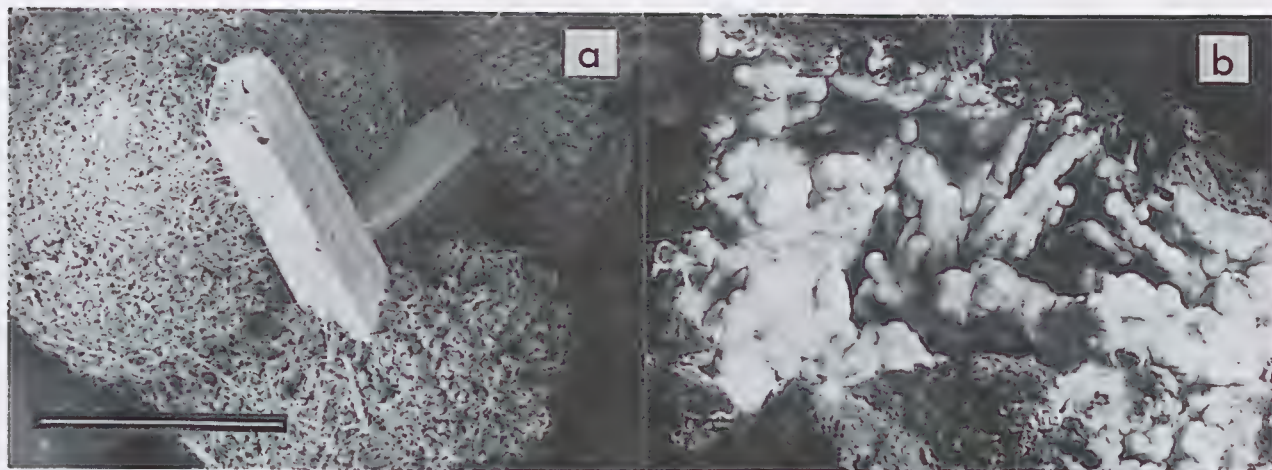
### MODE OF OCCURRENCE

Three specimens exemplify the habits exhibited by gibbsite at Dundas, two of which are examined in detail:

**D42734** Crocoite with gibbsite, Tasmania. Partly limonitised gossan block, coated with 0.5–10 mm long, 0.1–0.2 mm wide, acicular prisms of vermilion crocoite, invested with tufts and balls of white, microcrystalline gibbsite (pl. 1A).

**D46576** Crocoite with gibbsite, Adelaide Mine, Dundas, Tasmania. Matted 5–15 mm long, 0.1–1 mm wide, acicular and bladed prisms of bright vermilion crocoite in cavernous ferromanganese gossan, partly coated by pisolitic stalactites of gibbsite, fingers of which rise 10 mm above the surface and are up to 3 mm thick (pl. 1B).

**D44000** Crocoite partly replaced by gibbsite, Adelaide Mine, Dundas, Tasmania. Irregular, 200  $\times$  250  $\times$  200 mm mass of



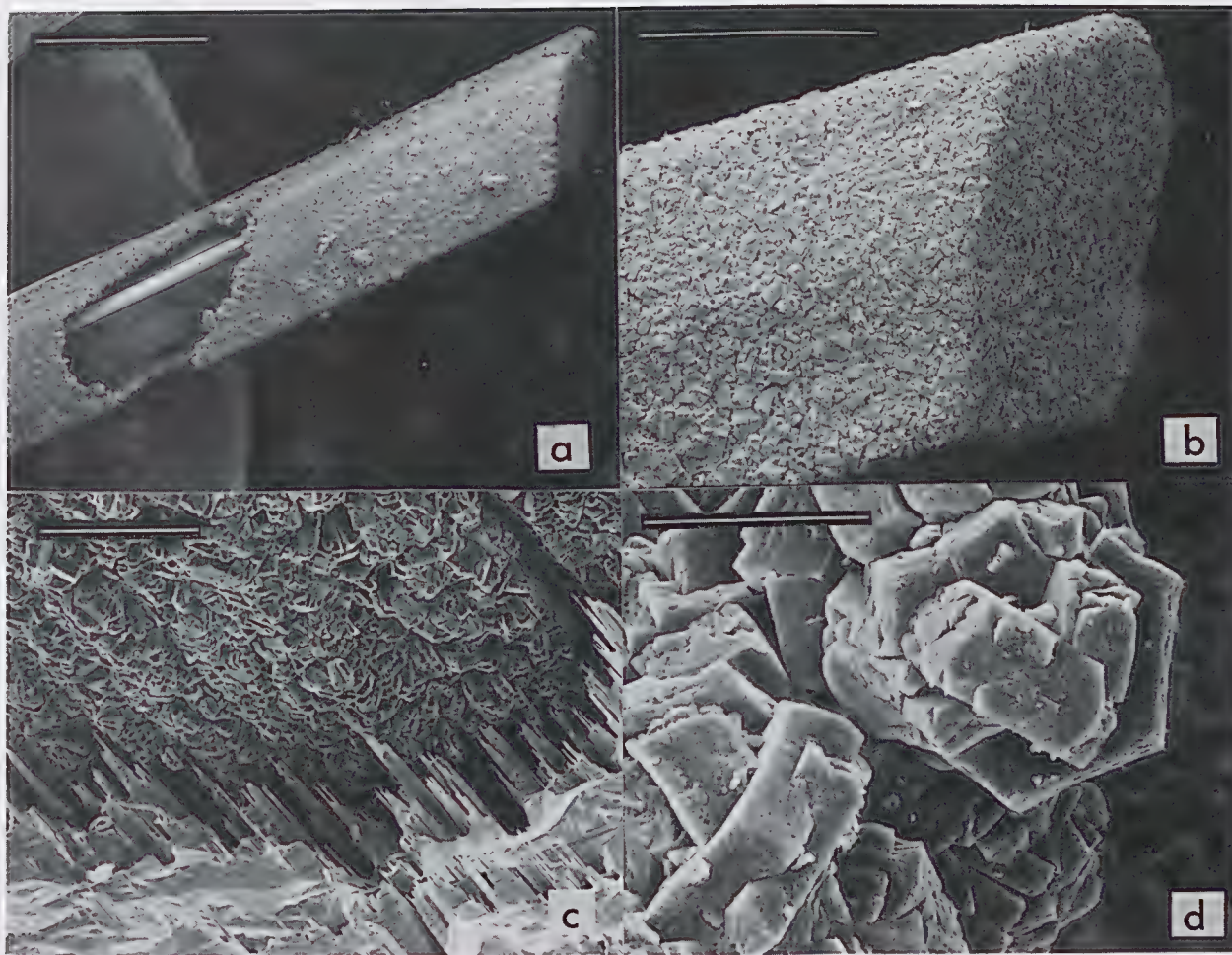
## PLATE 1

(a) Scanning electron micrograph of multicrystal balls of gibbsite investing crocoite prisms. In this encrusting mode, crocoite has remained passive throughout precipitation of gibbsite. Haupt (1988: 385) noted that "chemical methods for removing [gibbsite] without harm to the underlying crocoite have been developed." (Surface fibres are fungal hyphae.) Australian Museum specimen D42734, Tasmania. Scale bar: 1 mm. (b) Pisolitic stalactites of gibbsite lining vug in gossan containing abundant bright crocoite needles. Australian Museum specimen D46576, Dundas, Tasmania. Base of photo is approximately 100 mm.



## PLATE 2

Prismatic crocoite crystals partly pseudomorphed by gibbsite (white). The prisms are hollow throughout much of their length where they have been more or less replaced with gibbsite, including their former terminations. Near their attachment, the crystals are solid, although having hollow cores whose inner surfaces are also replaced by gibbsite. Australian Museum specimen D44000, Dundas, Tasmania. Base of photo is approximately 45 mm.



## PLATE 3

Scanning electron micrographs of gibbsite-crocoite association, Dundas, Tasmania. Australian Museum specimen D44000. (A) Broken, hollow, prismatic crystal of crocoite with termination totally replaced by crystalline gibbsite mosaic. Original crocoite forming inner wall of the crystal tube can be seen through hole. The portion of crystal below hole is a dull scarlet and the surface here is studded with gibbsite crystallites. Scale bar: 2 mm. (B) Similar termination to that in (A). Scale bar: 500  $\mu\text{m}$ . (C) Crocoite-gibbsite tube broken close to solid crocoite crystal base. Multicrystal gibbsite tube wall above, splintered crocoite below; splinters at margins conforming to grooves in gibbsite aggregate. Scale bar: 200  $\mu\text{m}$ . (D) Aggregate of tabular, pseudohexagonal crystals of gibbsite on broken edge of pseudomorphed termination. Scale bar: 50  $\mu\text{m}$ .

yielding abundant, transparent to partly occluded crystal fragments. Raman spectra recorded using laser power of 1000 mW yielded an excellent gibbsite "fingerprint" with strong v-OH stretching bands at about 3370, 3440, 3525, 3620  $\text{cm}^{-1}$ , the results closely approximating those of Huneke *et al.* (1980) and Rodgers *et al.* (1991). The same spectrum was returned by direct laser examination of the remaining original ball surface.

Several pseudomorphed crystals were scanned from D44000; the laser being focused directly on the virgin surface of the crystal prisms. Typical results were demonstrated by the partly broken, off-white termination of one former 15 mm crocoite crystal, which gave a clear gibbsite spectrum with a strong background fluorescence that decreased sharply with increasing wavenumber. A smaller but complete, largely pseudomorphed crystal (similar to that in plate 3B) gave similar results, with signal to noise ratio being improved by increasing the laser power to c. 1500 mW (fig. 1).

Scans of white pseudomorph crystal tips of D44000, showing the least yellow colour, gave good gibbsite spectra

free of any crocoite bands in the region 100–1300  $\text{cm}^{-1}$  (fig. 2). Lower on the same prisms, where replaced portions of the crystals are more intensely stained, weak crocoite lines appear in the Raman spectra.

All gibbsite crystallites examined from this large specimen, D44000, appeared similar in size to the focused laser spot.

## Crocoite

Unsatisfactory crocoite spectra, but sufficient to confirm the identity of the mineral, were obtained from 100–1200  $\text{cm}^{-1}$  from several of the vermilion portions of crystals of D44000, using the green Ar<sup>+</sup> 514.5 nm line. The  $\text{CrO}_4^{2-}$  ion absorbs strongly over the range 24000–28000  $\text{cm}^{-1}$  (Campbell 1965) but transmits in the red and superior results were obtained by macrosampling untreated faces from these same crystals with the red Kr<sup>+</sup> laser (647.1 nm) and an Anaspec-Cary 81 spectrometer. The example shown in figure 3 closely matches the result obtained by Wilkins (1971) for an unlocated Tasmanian crocoite and is broadly

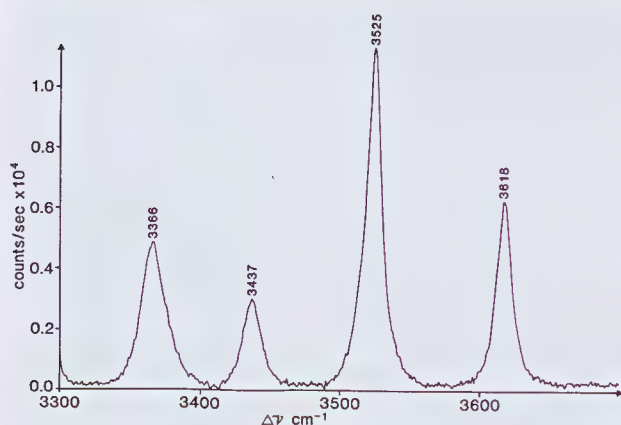


FIG. 1 — Microprobe laser Raman spectrum of Dundas gibbsite, pseudomorphing crocoite from 3330–3700  $\text{cm}^{-1}$ . Australian Museum specimen D44000.

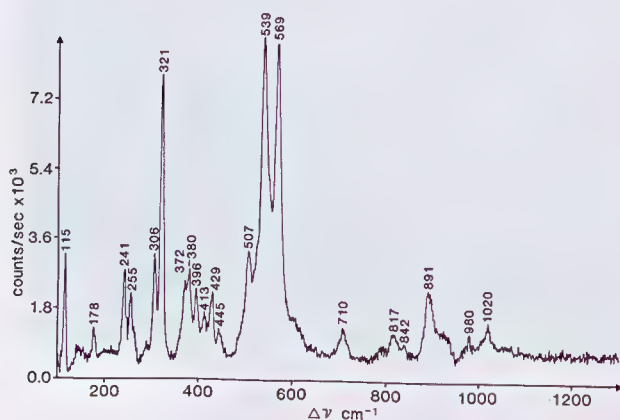


FIG. 2 — Microprobe laser Raman spectrum of Tasmanian gibbsite, investing crocoite from 100–1300  $\text{cm}^{-1}$ . Australian Museum specimen D42734.

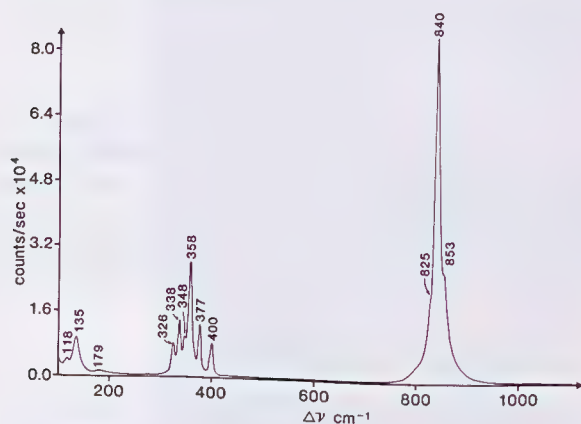


FIG. 3 — Laser Raman spectrum of Dundas crocoite from 100–1200  $\text{cm}^{-1}$ . Australian Museum specimen D44000.

comparable to that obtained by Scheuermann *et al.* (1970) from a polished crocoite single crystal cut normal to  $c$ . This arrangement avoided scrambling of polarisation of the incident and scattered radiation caused by polycrystalline reflections, and produced a spectrum exhibiting finer structural detail than obtained by Wilkins (1971) or the present study.

Band assignments for crocoite, following Scheuermann *et al.* (1970) and Wilkins (1971), are:

$\nu_1(A_1)$  840  $\text{cm}^{-1}$  (symmetric stretching of  $\text{CrO}_4^{2-}$ );  
 $\nu_3(F_2)$  853, 825  $\text{cm}^{-1}$  (asymmetric stretching of  $\text{CrO}_4^{2-}$ );  
 $\nu_2(E)$  348  $\text{cm}^{-1}$  (bending deformation of  $\text{CrO}_4^{2-}$ );  
 $\nu_4(F_2)$  400, 377, 358, 338, 326  $\text{cm}^{-1}$  (bending vibration of  $\text{CrO}_4^{2-}$ );  
 179, 135, 118  $\text{cm}^{-1}$  crystal field components of  $\text{Pb-O}$  vibrations and lattice modes.

## DISCUSSION

Results obtained here demonstrate the versatility of the laser Raman microprobe in identifying the crystal chemistry of fine-grained compounds in a non-destructive manner. However, the experimental results shed scant light on the late paragenetic history of the Dundas ores.

A complex sequence of mineralisation has affected the Dundas district (Reid 1925, Blissett 1962). Following emplacement of the primary ore, secondary deposition occurred in fissure-replacement bodies. In the main, the secondary minerals within oxidised ore appear to have been derived from the primary minerals, and solution migration of metallic elements has been limited. Crocoite has formed late in a probable supergene sequence, and conventional wisdom regards the mineral as a product of oxidation of primary chromite in serpentinite wall rocks with solution of the chromium, and the subsequent reaction of this species with lead liberated from the primary ore. However, without any information on the chemistry of the mineralising fluids, the late paragenesis of the Dundas ores can only be conjectured.

Existing accounts of mineral paragenesis in the region make little reference to the role of gibbsite within the oxidised gossan ores. Clearly it is late, arguably the latest major mineral in the sequence. Among the wide range of minerals deposited earlier in the Dundas ores, few are aluminous. If aluminium was a component of the mineralising fluids, conditions did not favour it precipitating as part of a solid phase. Slightly acid to neutral conditions favour the precipitation of gibbsite, but it is seldom possible to define the conditions of formation of an aluminium hydroxide deposit from the crystal chemistry of its present day component(s) (Rodgers *et al.* 1991). In the case of Dundas, any attempt to draw conclusions is confounded by gibbsite replacing crocoite in one instance and investing it in another. This apparent dual facility of gibbsite to precipitate upon stable crocoite, as well as to crystallise at the same mineral's expense, may indicate that the stability fields of the two minerals overlap in a manner similar to that deduced by Southwood & Vilgoen (1986) for coexisting crocoite and vauquelinite in a silver-lead deposit in the Transvaal. However, the contrasting textural evidence at Dundas may also reflect the influence of kinetic factors in the formation of gibbsite, rather than purely thermodynamic considerations, as Nickel (1984) demonstrated for a pyrite-sulphur-jarosite pseudomorph assemblage. The investment of crocoite crystals could be consistent with rapid nucleation,

the pseudomorphism of delicate crystals suggesting a more extended gibbsitisation.

## ACKNOWLEDGEMENTS

This study was supported by a Visiting Fellowship awarded by the Australian Museum. Thanks are due to Professor Ralph Cooney, Drs Bill Baker, Bill Birch, Ralph Bottrill and F.L. Sutherland, Geoff Avern, Carl Bento, Mary Kumvaj and Ryszard Ratajczak for assistance and/or useful comment. Dr John Seakins assisted with the krypton laser spectrometry. Ross Pogson granted access to specimens in his care. Equipment funding was provided by the University of Auckland Research Committee, the University Grants Committee, and the New Zealand Lottery Grants Board (Scientific).

## REFERENCES

- ANDERSON, C., 1906: Mineralogical notes: No. III — Axinite, petterdite, crocoite, and datolite. *Rec. Aust. Museum* 6(3): 133–144.
- BANCROFT, P., 1984: *GEM AND CRYSTAL TREASURES*. Western Enterprises, Fallbrook California: 488pp.
- BLISSETT, A. H., 1962: *Zeehan, Tasmania*. Tasm. Dep. Mines 1 Mile Geol. Atlas Ser. Explan. Rep., Sheet 50 (7914S).
- CATALOGUE OF THE MINERALS OF TASMANIA, 1970: *Tasm. Dep. Mines Geol. Surv. Rec.* 9: 110pp.
- CAMPBELL, J.A., 1965: Spectral evidence for interionic forces in crystals — chromates and dichromates. *Spectrochim. Acta* 21: 1333–1348.
- COONEY, R.P., RODGERS, K.A. & GREGORY, M.R., 1989: Laser Raman spectrum of bayerite from Raoul Island, Kermadec Group, South Pacific. *Vulkanologiya i Seismologiya* part 5: 97–99 [in Russian].
- HAUPT, J., 1988: Minerals of western Tasmania. *Miner. Rec.* 19: 381–388.
- HUNEKE, J.T., CRAMER, R.E., ALVAREZ, R. & EL-SWAIFY, S.A., 1980: The identification of gibbsite and bayerite by laser Raman spectroscopy. *Am. Soil Sci. Soc.* 44: 131–134.
- LANCASTER, K., 1977: Crocoite and its increasing scarcity. *Miner. Rec.* 8(1): 24–26.
- NICKEL, E.H., 1984: An unusual pyrite–sulphur–jarosite assemblage from Arkaroola, South Australia. *Miner. Mag.* 48: 139–142.
- PALACHE, C., 1896: Crocoite from Tasmania. *Am. J. Sci., 4th series*, 1: 389–390.
- PETTERD, W.F., 1894: A catalogue of the minerals known to occur in Tasmania, with notes on their distribution. *Pap. Proc. R. Soc. Tasm.* 1893: 1–72.
- PETTERD, W.F., 1902: The minerals of Tasmania. *Pap. Proc. R. Soc. Tasm.* 1901: 75–84.
- REID, A.M., 1925: The Dundas mineral field. *Tasm. Dep. Mines Geol. Surv. Bull.* 36: 1–98.
- RODGERS, K.A., GREGORY, M.R. & COONEY, R.P., 1989: Bayerite,  $\text{Al}(\text{OH})_3$ , from Raoul Island, Kermadec Group, South Pacific. *Clay Mins* 24: 531–538.
- RODGERS, K.A., GREGORY, M.R. & BARTON, R., 1991: Bayerite, nordstrandite, gibbsite, brucite, and pseudoboehmite in discharged caustic waste from Campbell Island, southwest Pacific. *Clays, Clay Mins* 39: 103–107.
- SCHEUERMANN, W., RITTER, G.J. & SCHUTTE, C.J.H., 1970: The vibrational spectra of strontium chromate ( $\text{SrCrO}_4$ ) and lead chromate ( $\text{PbCrO}_4$ ). *Z. Naturforschung* 25A: 1856–1862.
- SOUTHWOOD, M.J. & VILGOEN, E.A., 1986: Lead chromate minerals from the Argent lead–silver mine, Transvaal, South Africa: crocoite, vauquelinite, and a possible second occurrence of embryite. *Miner. Mag.* 50: 728–730.
- WILKINS, R.W.T., 1971: The Raman spectra of crocoite. *Miner. Mag.* 38: 249–250.

(accepted 7 February 1992)



## THE CONSERVATION STATUS OF FRESHWATER MACRO-INVERTEBRATES IN THE BUCKLAND MILITARY TRAINING AREA, SOUTHEASTERN TASMANIA

by Pierre Horwitz and Jane Andrew

(with three tables and one text-figure)

HORWITZ, P. & ANDREW, J., 1992 (31:x): The conservation status of freshwater macro-invertebrates in the Buckland Military Training Area, southeastern Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 101–108. Centre for Environmental Studies, University of Tasmania, GPO Box 252C, Hobart, Tasmania 7001; (PH now Edith Cowan University, Joondalup Drive, Joondalup WA, Australia 6027).

The freshwater macro-invertebrate fauna of the Buckland Military Training Area near Triabunna on the east coast of Tasmania was investigated in April 1991. A total of 97 taxa were identified from ten sites, of which only about half could be assigned to species level and given a conservation status. Only one of these was deemed significant from a conservation viewpoint; at least eight others plus all the unknown species require further investigation to clarify their status.

About half of the species were found at only one site; the most similar sites were from permanent water at lower altitudes (although in different catchments). Species from lowland sites were well known and could be readily identified (often having broad distributional ranges over southeastern Australia). The upland site from a rainforest creek contained a high proportion of species not found elsewhere in the study, as did other upland temporary water bodies. Introduced fish and forestry activity are likely to represent the most serious threats to the faunal assemblage in the area.

**Key Words:** macro-invertebrates, freshwater fauna, Tasmania.

### INTRODUCTION

Tasmania is widely recognised as a haven for freshwater fauna, particularly those species adapted to cool conditions but there is a great deal of climatic variation within the state. The eastern half is conspicuously drier than the western half. Eastern Tasmania has small pockets of wetter areas, and this topographical variability is translated into habitat variation for freshwater organisms. Superimposed on this is a considerable amount of degradation and alteration of the original character of the area since the European invasion.

Within this widespread degraded and altered habitat, the Buckland Military Training Area (BMTA) has remained relatively intact, with only parts of the area having been disturbed by clear fell and hot burn logging activity, some grazing, military operations and recreational activities. The BMTA has a range of freshwater habitats over an altitudinal range of about 600 m, including *Sphagnum* or heathy swamps, temporary and permanent creeks in dry sclerophyll, wet sclerophyll or rainforested areas, and artificial impoundments (fire dams). The BMTA lies some 80 km by road from Hobart, north and northwest of Buckland, Orford and Triabunna, where it occupies an area of approximately 15 km × 21 km. The present work was part of a broader study aimed at describing the flora, fauna, geology, soils and archaeology of the BMTA, as part of an environmental impact assessment and land management plan for the Department of Defence (Hepper de Gryse Team 1991).

Prior to this work the BMTA had not been surveyed for its freshwater invertebrate assemblages, and there are, as yet, no available studies on these assemblages for any part of southeastern Tasmania. There is some ongoing work at the Tasmanian Inland Fisheries Commission on the feeding requirements of trout and the swan galaxias (*Galaxias fontanus*) (in the Swan and Macquarie Rivers), and three Honours students at the University of Tasmania have worked in the area.

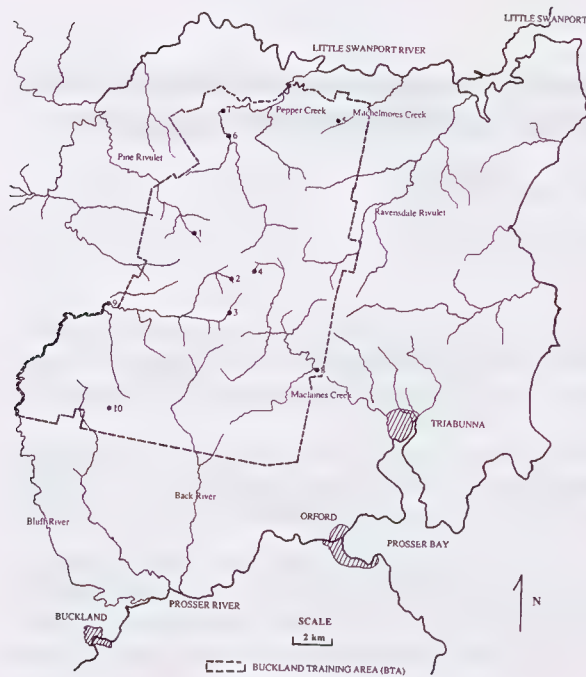
Of these, Bennison (1975) found that the Coal River, west of the BMTA, could be divided longitudinally into two zones: a lower region (potamon; altitude 110–20 m) and an upper region (rhithron; altitude 445–110 m). Invertebrates such as amphipods, caddis-flies, mayflies and some snail species were characteristic of upper reaches, whilst some snail species, dragonflies and water mites were characteristic of the lower region.

The aim of the present study was to undertake a “snapshot” survey of the BMTA over a range of habitats, in order to

- (1) provide an inventory of freshwater invertebrate species for the BMTA,
- (2) determine, where possible, the conservation status of the species, and
- (3) estimate the impacts of various activities (military operations, forestry, grazing etc.) on the fauna.

### METHODS

In addition to the variety of aquatic and semiaquatic habitats over its altitudinal range, the BMTA crosses several catchments, being drained by tributaries of the Prosser River in the south (Bluff River and Back River), Little Swanport River in the north (Pine Rivulet, Pepper Creek and Mitchelmores Creek), and Maclaines Creek and Ravensdale Rivulet in the east (fig. 1). In order to sample as much of the geographic variability as possible, sites were selected to include the aquatic faunas of each of the major drainages, at a range of altitudes and in different habitats. There were ten sampling sites in all. Five were from temporary pools in creeks in headwater regions, including one marsh (recently burnt), the pools in the headwaters of three creeks, and one creek in rainforest (sites 1–5). Four were chosen from the lowland sections of rivers, three from flowing, rocky sections, and one from amongst emergent vegetation adjacent to a deep pool in the channel of one of the rivers (sites 6–9). The final site was an anthropogenic water source (a fire dam,



site 10). The locations of the sites are given in figure 1. Sites 1–4 were sampled on 15 April 1991, sites 5–7 on 16 April, and sites 8–10 on 17 April 1991.

At each site, a Freshwater Biological Association net of mesh pore size 0.95 mm was used to collect freshwater invertebrates from one or more of four categories: (1) amongst submerged leaf litter (and other organic debris), (2) amongst submerged riparian vegetation, where it overhung the water, (3) amongst submerged and emergent aquatic vegetation, (4) on the surface of rocks (by gently brushing and washing them).

Samples from each microhabitat were combined for each site and were washed into a plastic bag for transportation. Each sample was rinsed in tap water and washed through a sieve of 500 µm mesh pore size, before being sorted in a white tray within 12 hours of collection. Invertebrates were preserved in 75% ethanol, and later identified to species level where possible.

FIG. 1 — Location of the ten sampling sites in the Buckland Military Training Area on the east coast of Tasmania.

Table 1  
Sites sampled within the BMTA

| Site | Location        | Site description                                                                                                                                                                                    | Water<br>Permanence* | Altitude†<br>Category<br>(m) | Microhabitat‡<br>Category<br>Sampled |
|------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------------------|--------------------------------------|
| 1    | Dolans Marsh    | Small pools in a narrow channel of a marsh; clear water pools with thick fibrous algal growths, site burnt three months prior to sampling.                                                          | T                    | U (430)                      | 1, 3                                 |
| 2    | Bluff R.        | Small rocky turbid pool in headwaters of river, fed by a small trickle, in regeneration area                                                                                                        | T                    | U (435)                      | 1, 2, 4                              |
| 3    | Baldy Ck        | Small rocky creek with clear flowing water in rain-forest in headwaters of Baldy Ck (Bluff River).                                                                                                  | T                    | U (425)                      | 1, 4                                 |
| 4    | Maclaines Ck    | Small rocky turbid pool in headwaters of creek, fed by a small trickle which becomes subterranean downstream. Regeneration Area.                                                                    | T                    | U (450)                      | 1, 2, 4                              |
| 5    | Mitchelmores Ck | Tributary of creek, pool with clear water in rocky creek.                                                                                                                                           | T                    | L (160)                      | 1, 4                                 |
| 6    | Pepper Ck       | Rocky pools with clear running water in gorge of creek. Aquatic vegetation <i>Myriophyllum salsgineum</i> .                                                                                         | P                    | L (175)                      | 1, 2, 3, 4                           |
| 7    | Pepper Ck       | Deep (>1 m) darkish pool in slow flowing part of creek, aquatic vegetation including <i>Typha</i> sp., <i>Eleocharis acuta</i> , <i>Myriophyllum aquaticum</i> , <i>Potamogeton tricarlinatus</i> . | P                    | L (120)                      | 3                                    |
| 8    | Maclaines Ck    | Rocky pools with clear running water.                                                                                                                                                               | P                    | L (90)                       | 1, 2, 4                              |
| 9    | Bluff R.        | Slimy rocks in long pools of river, with clear running water. Aquatic vegetation <i>Myriophyllum simulans</i> .                                                                                     | P                    | L? (280)                     | 1, 2, 4                              |
| 10   | Fire Dam        | Slightly turbid fire dam near <i>Sphagnum</i> bog. Aquatic vegetation including <i>Scirpus fluitans</i> , <i>Ranunculus rivularis</i> , <i>Elatine gratioloides</i> .                               | P?                   | U? (360)                     | 1, 2                                 |

\* T = temporary, P = permanent; † U = upland, L = lowland; ‡ see text.

The characteristics, estimated altitudes and microhabitat categories (as above) of each site are given in table 1.

Physico-chemical characteristics of the water were measured on site. The water temperature for upland sites (sites 1–4) was 8.0–11.5°C; for remaining sites, temperatures varied between 9.5 and 12.7°C. The pH of the water at the sampling sites was between 7.2 and 7.8. Conductivity values were more variable: upland sites 2, 3, and 4, and the fire dam (site 10) had K18 values of 200 µS/cm or lower; upland site 1 had a value of over 500 µS/cm, presumably because the area had just been burnt and recent rain had fallen; lowland sites had K18 values of between 230 and 1300 µS/cm.

From information in the literature, each taxon was assigned a conservation status; categories chosen included those used by the IUCN (Wells *et al.* 1983: Rare, Vulnerable, Endangered, Indeterminately Threatened [I], and potentially threatened or Insufficiently Known [K]). For the purposes of this study the status of “Unknown” (U) was applied to taxa for which a species identification was not possible and/or for which distributional information was unavailable. Similarly the status of “Apparently Not Threatened” (ANT) was applied to species which were not described in the literature as being rare or uncommon, did not appear in a review of the conservation of Tasmanian invertebrates (Greenislade, in press), nor were named in a recent census (involving taxonomic experts) of threatened invertebrates in Tasmania conducted by Horwitz & Smith.

No attempt was made to estimate the abundance levels of taxa. For organisms identified to species level, estimates of distribution were made (either found in southeastern Australia [SEA], endemic to Tasmania [END] or endemic to southeastern Tasmania [SET]).

Sites were compared by

- (1) estimating species richness by summing the number of species found at each site,
- (2) undertaking site comparisons by constructing a table of similarities based on the presence of the same taxa at each site (coefficient of similarity), and
- (3) calculating the number of species that were found exclusively at each site (number of local endemics).

## RESULTS

An inventory of the freshwater macro-invertebrate species found in the BMTA is given in table 2, showing the presence of taxa at each site.

Most of the major groups of freshwater invertebrate species were represented in the BMTA. Ninety-seven taxa were recorded during the survey, representing at least this many species. Distributional and taxonomic information for many of the taxa was not available in the literature; thus, 50 taxa are designated as having an unknown conservation status (“U” in table 2).

The remaining 47 species were deemed to be sufficiently understood to make judgements about their conservation status. None of them are known to have been introduced to Tasmania or to the BMTA, although the 18 taxa which were found in the fire dam have had their local distributions extended by the creation of such impoundments.

Thirty-eight species (81% of the 47 well-understood species) are apparently not threatened (in Tasmania). Of these species:

- (1) many occur throughout at least southeastern Australia (refer to table 2),
- (2) comparatively few are Tasmanian endemics, these endemics include the phreatoicid shrimps, the water pennies *Sclerocyphon aquaticus* and *S. secretus*, the stoneflies *Leptoperla varia* and *Eusthenia spectabilis*, and the damselfly *Ischnura heterosticta tasmanica*.

## Significant Species

None of the 47 species could be placed into the categories of Rare, Vulnerable or Endangered; however, there are nine species in the BMTA which are or could be of significance from a conservation viewpoint:

- (1) the snail *Fluvidona* sp., which is found throughout eastern Tasmania but may well contain locally restricted species or genotypes (given the occurrence of the latter for other members of the genus; W. Ponder, pers. comm.); no information is known about the species collected in the BMTA, except that the snails were recorded at four of the nine sites, three lowland rivers and one temporary creek;
- (2) a water bug found in the rainforest creek which belongs to the genus *Microvelia* but did not conform to any of the species known to occur in Tasmania (determined from a key to Tasmanian species made available by Lansbury & Lake); these are, therefore, either variants of previously described species, or species which have not previously been found in Tasmania, or a new species;
- (3) the water bug *Agraptocorixa parvipunctata*, which is reported to be uncommon in Tasmania (Lansbury & Lake, unpubl.); this was found in the fire dam and in a lowland water course;
- (4) the water beetles *Carabhydrus niger* and *Australphilus saltus*, both known from very few localities in Tasmania (Horwitz, unpubl., Watts, 1978); these were found amongst vegetation in the fire dam, and in a lowland water course;
- (5) the mayfly genus *Koorrnonga*, found at six sites, which is not otherwise known from eastern Tasmania (possibly due to the lack of knowledge of the mayfly fauna of eastern Tasmania; S. Chilcott, pers. comm.);
- (6) the dragonfly *Austroaeschna tasmanica*, which is endemic to Tasmania and considered to be uncommon and vulnerable to disturbance (Allbrook, pers. comm.); it was found amongst submerged vegetation in a lowland water course;
- (7) the damselfly *Austrolestes io*, which is found in southeastern Australia but considered to be uncommon in Tasmania (Allbrook 1979); this was found in the fire dam and two lowland water courses;
- (8) the mecopteran belonging to the genus *Nannochorista*, which has not previously been found in eastern Tasmania; it was found only at the rainforest creek.

Each of the species described above (with the exception of *Austroaeschna tasmanica*) has been referred to for the purposes of this study as being “insufficiently known”. Several sites contained three or more of these important species, for instance, the rainforest creek (site 3, four species), a slow-flowing lowland water course (site 7, four species), and the fire dam (site 10, three species).

Table 2 Inventory of freshwater macro-invertebrate species found in the BMTA

Shows the common names of the major taxonomic groups, the species designation, the presence (x) of each species from each site and the total species present at each site. Codes for the conservation status and the distribution are given under "Methods" above.

| CLASS/ORDER<br>common names                       | Family         | Species                            | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Conservation<br>Status | Distribution |
|---------------------------------------------------|----------------|------------------------------------|---|---|---|---|---|---|---|---|---|----|------------------------|--------------|
| OLIGOCHAETA<br>Worms                              |                | Unidentified sp. or spp.           |   |   | x | x |   |   |   |   | x |    | U                      |              |
| GASTROPODA<br>Snails                              | Ancylida       | <i>Ferrissia tasmanica</i>         |   |   |   |   | x |   | x |   | x |    | ANT                    | SEA          |
|                                                   | Hydrobiidae    | <i>Fluvidona</i> sp.               |   |   |   |   | x | x |   | x | x |    | K                      | END          |
|                                                   | Lymnaeidae     | <i>Austropeplea tomentosa</i>      |   |   |   |   |   |   | x |   | x |    | ANT                    | SEA          |
|                                                   | Planorbidae    | <i>Isidorella hainesii</i>         |   |   |   |   |   |   |   |   | x |    | ANT                    | SEA          |
| BIVALVIA<br>(Bivalves, "mussels")                 | Sphaeriidae    | <i>Pisidium casteranum</i>         | x |   | x |   |   | x | x | x | x | x  | ANT                    | SEA          |
|                                                   | Sphaeriidae    | <i>Sphaerium tasmanicum</i>        |   |   |   |   |   |   |   |   |   | x  | ANT                    | SEA          |
| ARACHNIDA/<br>ACARINA<br>Water mites              | Arrenuridae    | <i>Arrenurus</i> sp.               |   |   |   |   |   |   | x |   |   |    | U                      |              |
|                                                   | Hydrachnidae   | <i>Hydrachna</i> sp.               |   |   | x |   |   |   |   |   |   |    | U                      |              |
|                                                   | Limnochareidae | <i>Rhyncholimnocharis</i> sp.      |   |   |   |   |   |   |   |   |   | x  | U                      |              |
|                                                   | Oxidae         | <i>Flabellifrontipoda</i> sp.      |   |   |   |   |   |   |   |   | x |    | U                      |              |
|                                                   | Hygrobates     | <i>Australiobates</i> sp.          |   |   |   |   |   |   |   |   | x |    | U                      |              |
| CRUSTACEA/<br>ISOPODA<br>(Crustaceans, shrimps)   | Phreatoicoidea | <i>Paraphreatoicus</i> sp.         | x |   |   |   | x |   |   |   |   |    | ANT                    | END/SET      |
| CRUSTACEA/<br>AMPHIPODA<br>(Crustaceans, shrimps) | Paramelitidae  | <i>Antipodeus</i> sp.              | x |   | x | x | x |   |   |   |   |    | U                      | END?         |
|                                                   | Ceinidae       | <i>Austrochiltonia australis</i>   |   |   |   |   |   |   | x |   | x |    | ANT                    | SEA          |
| CRUSTACEA/<br>DECAPODA<br>(Crustaceans, shrimps)  | Atyidae        | <i>Paratya australiensis</i>       |   |   |   |   |   | x | x | x | x |    | ANT                    | SEA          |
| INSECTA/<br>HEMIPTERA<br>Water bugs               | Veliidae       | <i>Microvelia dubia</i>            |   |   | x |   |   |   |   |   |   |    | ANT                    |              |
|                                                   |                | <i>Microvelia peramoena</i>        |   |   |   |   |   | x | x |   |   |    | ANT                    | SEA          |
|                                                   |                | <i>Microvelia</i> ?sp.             |   |   | x |   |   |   |   |   |   |    | K                      |              |
|                                                   | Mesoveliidae   | <i>Mesovelia hungerfordii</i>      |   |   |   |   |   | x | x | x |   |    | ANT                    | SEA          |
|                                                   | Notonectidae   | <i>Anisops thienemanni</i>         | x |   |   |   |   |   |   |   |   |    | ANT                    | SEA          |
|                                                   |                | <i>Anisops deanei</i>              |   |   |   |   |   |   |   |   |   | x  | ANT                    | SEA          |
|                                                   |                | <i>Enithares woodwardi</i>         |   |   |   |   |   |   |   |   |   | x  | ANT                    | SEA          |
|                                                   | Corixidae      | <i>Micronecta annae illiesi</i>    |   |   |   |   |   |   |   |   | x |    | ANT                    |              |
|                                                   |                | <i>Agraptocorixa parvipunctata</i> |   |   |   |   |   |   | x |   |   | x  | K                      | SEA          |
|                                                   |                | <i>Sigara australis</i>            |   |   |   |   |   |   |   |   |   | x  | ANT                    | SEA          |
|                                                   | Naucoridae     | <i>Naucoris congrex</i>            |   |   |   |   |   |   |   |   |   | x  | ANT                    | SEA          |
| INSECTA/<br>COLEOPTERA<br>Water beetles           | Dytiscidae     | <i>Australphilus saltus</i>        | x |   |   |   |   |   | x |   |   | x  | K                      | SEA          |
|                                                   |                | <i>Necterosoma penicillatus</i>    |   |   |   | x |   |   | x | x |   | x  | ANT                    | SEA          |
|                                                   |                | <i>Antiporus femoralis</i>         |   |   |   |   |   |   | x |   |   |    | ANT                    | SEA          |
|                                                   |                | <i>Antiporus blakei</i>            |   |   |   |   |   |   | x |   |   |    | ANT                    | SEA          |
|                                                   |                | <i>Sternopriscus hansardi</i>      |   |   |   |   |   |   |   |   |   | x  | U                      |              |
|                                                   |                | <i>Carabhydrus niger</i>           |   |   |   |   |   |   |   | x |   |    | K                      | SEA          |
|                                                   | Psephenidae    | <i>Sclerocyphon aquaticus</i>      |   |   |   |   |   | x | x | x | x |    | ANT                    | END          |
|                                                   |                | <i>Sclerocyphon secretus</i>       |   | x |   |   |   |   |   |   |   |    | ANT                    | END          |
|                                                   | Helminthidae   | <i>Austrolimnius</i> sp.           |   |   | x |   |   |   |   |   |   |    | U                      |              |
|                                                   |                | sp. 2                              |   |   | x |   |   |   |   |   |   |    | U                      |              |
|                                                   | Hydrophilidae  | sp. 1                              |   |   | x |   | x |   | x |   |   |    | U                      |              |
|                                                   |                | sp. 2                              |   |   |   |   |   |   |   |   |   | x  | U                      |              |
|                                                   | Helodidae      | sp. 1                              |   |   | x |   |   |   |   |   |   |    | U                      |              |
| INSECTA/<br>DIPTERA<br>Fly larvae                 | Chironomidae   | <i>Chironomus</i> sp. 1            |   |   | x |   |   | x |   |   |   |    | U                      |              |
|                                                   |                | <i>Chironomus</i> sp. 2            | x |   | x |   |   |   | x |   | x |    | U                      |              |
|                                                   |                | <i>Chironomus</i> sp. 3            |   |   |   |   |   | x |   | x | x |    | U                      |              |
|                                                   |                | <i>Chironomus</i> sp. 4            | x | x | x | x |   |   |   | x | x |    | U                      |              |
|                                                   |                | ? <i>Procladius</i> sp.            |   |   |   |   |   | x |   |   |   |    | U                      |              |
|                                                   |                | <i>Apsectrotanytus</i> sp.         |   |   |   |   |   |   | x |   |   |    | U                      |              |

Table 2 cont.

| CLASS/ORDER<br>common names            | Family            | Species                                | Site |   |    |    |   |    |    |    |    |    | Conservation<br>Status | Distribution |
|----------------------------------------|-------------------|----------------------------------------|------|---|----|----|---|----|----|----|----|----|------------------------|--------------|
|                                        |                   |                                        | 1    | 2 | 3  | 4  | 5 | 6  | 7  | 8  | 9  | 10 |                        |              |
|                                        | Ceratopogonidae   | sp. 1                                  |      |   | x  |    |   | x  |    | x  | x  |    | U                      |              |
|                                        | Culicidae         | (Culicini)                             | x    |   | x  | x  | x | x  | x  |    |    |    | U                      |              |
|                                        |                   | (Anophelini)                           |      |   | x  | x  |   |    |    |    |    |    | U                      |              |
|                                        | Dixidae           | <i>Dixa</i> sp.                        |      |   |    |    |   | x  | x  | x  |    |    | U                      |              |
|                                        | Simuliidae        | ? <i>Austrosimulium</i> sp.            |      |   |    |    |   |    |    |    | x  |    | U                      |              |
|                                        | Tipulidae         | sp. 1                                  |      |   | x  |    |   |    |    |    |    |    | U                      |              |
|                                        | Athericidae       | sp. 1                                  |      |   | x  |    |   |    |    |    |    |    | U                      |              |
| INSECTA/<br>PLECOPTERA<br>Stoneflies   | Gripopterygidae   | <i>Trinotoperla</i> sp.                |      |   | x  |    |   |    |    |    |    |    |                        |              |
|                                        |                   | <i>Leptoperla varia</i>                |      |   |    |    |   | x  |    |    |    |    | ANT                    | END          |
|                                        |                   | <i>Dinotoperla bassae</i>              |      |   |    |    |   | x  | x  |    | x  |    | ANT                    | SEA          |
|                                        | Eustheniidae      | <i>Eusthenia spectabilis</i>           |      |   |    |    |   |    |    |    | x  |    | ANT                    | END          |
| INSECTA/<br>EPHEMEROPTERA<br>Mayflies  | Notonemouridae    | <i>Austrocercoides</i> sp.             |      |   | x  |    |   |    | x  |    | x  |    | U                      |              |
|                                        | Leptophlebiidae   | <i>Koornonga</i> sp.                   |      |   | x  | x  |   | x  | x  | x  | x  |    | K                      |              |
|                                        |                   | <i>Nousia</i> sp.                      |      |   | x  | x  | x | x  |    |    | x  |    | U                      |              |
|                                        |                   | <i>Atalophlebia australis</i>          |      |   |    |    |   |    | x  |    | x  |    | ANT                    | SEA          |
|                                        |                   | <i>Atalophlebia albiterminata</i>      |      |   |    |    |   |    |    |    | x  |    | ANT                    | SEA          |
|                                        |                   | Genus D (J. Dean)                      |      |   |    | x  |   |    |    |    | x  |    | U                      |              |
|                                        | Baetidae          | ? <i>Baetis</i> sp.                    |      |   |    |    |   |    |    |    | x  |    | U                      |              |
| INSECTA/<br>ODONATA<br>Dragonflies     | Caenidae          | <i>Tasmanocoenis</i> sp.               |      |   |    | x  |   | x  | x  | x  | x  |    | U                      |              |
|                                        | Aeshnidae         | <i>Austroaeschna parvistigma</i>       |      | x |    |    |   | x  |    | x  |    |    | ANT                    | SEA          |
|                                        |                   | <i>Austroaeschna tasmanica</i>         |      |   |    |    |   |    | x  |    |    |    | I                      | END          |
|                                        |                   | <i>Aeshna brevistyla</i>               |      |   |    |    |   |    | x  |    |    |    | ANT                    | SEA          |
|                                        | Gomphidae         | <i>Austrogomphus guerini</i>           |      |   |    |    |   | x  |    | x  |    |    | ANT                    | SEA          |
|                                        | Cordulidae        | <i>Hemicordulia tau</i>                |      |   |    |    |   |    | x  |    |    | x  | ANT                    | SEA          |
|                                        | Lestidae          | <i>Austrolestes io</i>                 |      |   |    |    |   |    | x  |    | x  | x  | K                      | SEA          |
| Damselflies                            |                   | <i>Austrolestes analis</i>             |      |   |    |    |   |    | x  |    | x  | x  | ANT                    | SEA          |
|                                        | Coenagrionidae    | <i>Ischnura heterosticta tasmanica</i> |      |   |    |    |   |    | x  |    |    |    | ANT                    | END          |
|                                        |                   | <i>Coenagrion lyelli</i>               |      |   |    |    |   |    | x  |    |    | x  | ANT                    | SEA          |
|                                        |                   |                                        |      |   |    |    |   |    |    |    |    |    |                        |              |
| INSECTA<br>TRICHOPTERA<br>Caddis flies | Leptoceridae      | sp. 1                                  |      | x | x  |    |   |    |    |    |    |    | U                      |              |
|                                        |                   | sp. 2                                  |      |   | x  |    |   |    |    |    |    |    | U                      |              |
|                                        |                   | sp. 3                                  |      |   | x  | x  |   |    | x  | x  | x  | x  | U                      |              |
|                                        |                   | sp. 4                                  |      | x |    | x  |   | x  |    |    |    | x  | U                      |              |
|                                        |                   | sp. 5                                  |      |   |    |    |   | x  | x  | x  | x  |    | U                      |              |
|                                        |                   | sp. 6                                  |      |   |    |    |   | x  | x  | x  | x  | x  | U                      |              |
|                                        |                   | sp. 7                                  |      | x |    |    |   |    |    |    |    |    | U                      |              |
|                                        |                   | sp. 8                                  |      |   |    |    |   |    | x  | x  |    |    | U                      |              |
|                                        |                   | sp. 9                                  |      |   |    |    |   |    | x  |    |    |    | U                      |              |
|                                        | Calocidae         | <i>Caenota plicata</i>                 |      | x | x  |    |   |    |    |    |    |    | ANT                    | SEA          |
|                                        |                   | <i>Tamasia variegata</i>               |      |   |    |    |   | x  |    |    | x  |    | ANT                    | SEA          |
|                                        | Tasimiidae        | <i>Tasimia</i> sp.                     |      |   | x  |    |   |    |    | x  |    |    | U                      |              |
|                                        | Helicopsychidae   | <i>Helicopsyche</i> sp.                |      |   |    |    |   | x  |    | x  |    |    | U                      |              |
|                                        | Atriplectididae   | <i>Atriplectides dubius</i>            |      |   |    |    |   |    | x  |    |    |    | ANT                    | SEA          |
|                                        | Odontoceridae     | ? <i>Marilia bola</i>                  |      |   |    |    |   |    |    |    |    |    | U                      |              |
|                                        | Polycentropididae | Genus I sp. 3                          |      |   |    |    |   | x  |    | x  |    |    | U                      |              |
|                                        |                   | <i>Plectrocnemia</i> sp.               |      |   |    | x  |   | x  | x  |    | x  |    | U                      |              |
|                                        | Ecnomidae         | <i>Ecnomus tillyardi</i>               |      |   |    |    |   |    |    | x  |    |    | ANT                    | SEA          |
|                                        |                   | <i>Ecnomina</i> F ?sp. 7               |      |   |    |    |   |    |    | x  | x  |    | U                      |              |
|                                        | Hydrobiosidae     | sp. 1                                  |      |   |    |    |   |    |    | x  |    |    | U                      |              |
|                                        | Hydroptilidae     | <i>Hellyethira simplex</i>             |      |   |    |    |   |    | x  |    |    |    | U                      | SEA          |
|                                        |                   | <i>Hellyethira</i> sp. 2               |      |   |    |    |   |    | x  |    |    |    | U                      |              |
| INSECTA /<br>MECOPTERA                 | Nannochoristidae  | <i>Nannochorista</i> sp.               |      |   | x  |    |   |    |    |    |    |    | K                      |              |
|                                        |                   |                                        |      |   |    |    |   |    |    |    |    |    |                        |              |
| TOTAL NUMBER OF SPECIES                |                   |                                        | 8    | 7 | 28 | 13 | 7 | 26 | 40 | 25 | 36 | 18 |                        |              |

Site Differences

Species richness varied considerably between sites (see Total Number of Species, table 2). Upland sites (sites 1, 2 and 4) and the temporary pool in the creek at site 5 yielded between seven and 13 species per site. In contrast, 28 species were recorded from the rainforest creek (the upper reaches of Baldy Creek, site 3), and between 25 and 40 species were recorded from lowland water courses (sites 6–9). Eighteen species were recorded from the fire dam. Site 7, the slow-flowing lowland water course, contained the highest species richness.

The similarities between each two sites, in terms of presence or absence of invertebrate taxa, and local endemism are shown in table 3. Several features of interest can be discerned from the data:

- (1) The lowland rivers and creeks (sites 6–9), although in separate water catchments, have comparatively high levels of species similarity, ranging from 22–48%. The highest level of similarity in the study was found between sites 6 and 8 (Pepper Creek and Maclaines Creek), despite the distance separating these creeks.
- (2) The upland sites had relatively low levels of similarity with the lowland rivers and creeks. This is exemplified by sites 1 and 2, which have levels of similarity of 0–8 % with sites 6–9. Eight odonatan species, four water beetles (Dytiscidae), three stonefly species, the shrimp *Paratya australiensis* and the amphipod *Austrochilonia australis* were absent from upland sites.
- (3) Eleven species were only found at the rainforest creek (site 3). Taxa which contributed to this high level of local endemism were three water beetles, a caddisfly, two dipterans and a mecopteran larva, a water mite and a stonefly.
- (4) The fire dam (site 10) had a faunal assemblage of which seven species were not found at any other site, including four water bugs, a bivalve, a water mite and a water beetle.

Table 3  
Similarity indices between sites\* and number of locally endemic species†.

| Site | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | Number of "Local Endemics" |
|------|---|----|----|----|----|----|----|----|----|----------------------------|
| 1    | 9 | 16 | 17 | 25 | 6  | 7  | 6  | 8  | 9  | 1                          |
| 2    | - | 9  | 12 | 0  | 6  | 0  | 7  | 0  | 9  | 2                          |
| 3    | - | -  | 24 | 13 | 10 | 8  | 13 | 16 | 5  | 11                         |
| 4    | - | -  | -  | 18 | 18 | 12 | 15 | 15 | 11 | 0                          |
| 5    | - | -  | -  | -  | 10 | 7  | 3  | 8  | 0  | 0                          |
| 6    | - | -  | -  | -  | -  | 24 | 48 | 24 | 7  | 2                          |
| 7    | - | -  | -  | -  | -  | -  | 22 | 22 | 20 | 11                         |
| 8    | - | -  | -  | -  | -  | -  | -  | 27 | 10 | 3                          |
| 9    | - | -  | -  | -  | -  | -  | -  | -  | 10 | 9                          |
| 10   | - | -  | -  | -  | -  | -  | -  | -  | -  | 7                          |

\* i.e., % of species which two sites share.  
† i.e., found nowhere else in this survey.  
‡ For site descriptions, see table 1. Total number of species, 97.

DISCUSSION

The freshwater fauna list described herein for the BMTA is affected by both the time of the year in which the survey was undertaken (a three-day period in April) and the method used to collect the samples.

It is quite likely that the same invertebrate sampling technique would have produced a different species list, if the sampling had been undertaken in a different season. These differences arise because, at any time of year, there will be species undergoing a part of their life cycle which means they are unlikely to be caught by a net. Similarly, the net mesh pore size means that freshwater animals of length or diameter less than 1 mm will be unlikely to be collected. Furthermore, since sampling effort was limited, the absence of a taxon from a sample does not necessarily mean that the taxon was absent from the site at the time of sampling.

These factors will tend to render too low the number of invertebrate species in the area as listed here. Encountering taxa which cannot be readily identified also exacerbates this problem. For all these reasons, the species list given in this report must not be interpreted as being complete.

Conservation Status of Freshwater Fauna

The invertebrate assemblage contains representatives of most major taxonomic groups which one would expect from southeastern Tasmania. In this respect, the assemblage is similar to that described for the Coal River (Bennison 1975) and from farm dams near Copping (Walker 1974, Blake 1991).

From the 47 species found in the BMTA for which a conservation status could be assigned, only one was regarded as being threatened and warranting special concern within the area. Otherwise, there appear to be no species which, by their rarity or susceptibility to extinction, should constrain activities within the BMTA. This conclusion must, however, be considered in the light of the limitations described above; there may be species which have not been found in this survey which are indeed threatened.

It should also be borne in mind that the well-known species are likely to be more common and, therefore, not rare or otherwise threatened. Our concern should be for those species which were assigned an "Unknown" status in the study, and more work is required to establish the taxonomic identity and status of these species.

The one species recognised as "indeterminately threatened", the dragonfly *Austroaeschna tasmanica*, is endemic to Tasmania, where it is uncommon and has had its range of available habitat reduced by clearing of riparian vegetation which overhangs the water (Allbrook 1979). Under these conditions it is replaced by the congeneric *A. parvistigma*. The presence of both species in the BMTA reinforces the need to avoid clearing of overhanging vegetation, to stabilise eroded or undercut banks, and to maintain riparian strips during forestry activity.

Three of the nine species recognised in this survey as being of conservation significance were found in a fire dam. In addition, 39% of the fauna in the fire dam were not recorded from any other site. Thus, artificial impoundments can provide an extra habitat or a refuge under conditions of stress for some local species, but also an opportunity for invasion by species not native to the area. The presence of dams, therefore, raises conservation issues in its own right.

The potential for dams to harbour rare or threatened freshwater fauna has been recorded from elsewhere in the world (e.g. dragonflies in South Africa; Samways 1989). Fire dams, as such, represent something of a quandary for the management of the BMTA, since they require special treatment for their fauna, yet the water in them may be required for control of fires.

The differences observed between lowland sites and upland sites in terms of the presence of species support the notion of longitudinal zonation for river systems in southeastern Tasmania (as described for the Coal River by Bennisson 1975). On the basis of these site comparisons, the rainforest and the slow-flowing lowland sites were recognised as being important, with high proportions of species which were not found at other sites.

It should be noted that the limitations on this set of data, caused by seasonal variation and limited sampling effort (as outlined above), would probably cause overestimates of site differences. On the other hand, taxonomically unresolved and closely related species, which separate by habitat or altitude, will be recorded as one species from two sites, when in actual fact they represent two or more species. Thus, differences between sites will be underestimated when using a parameter of species richness.

The rainforest creek is an example of an upland cool-cold clear stream. Such streams (whether permanent or temporary over summer) are of importance from a scientific point of view, because of the potential for them to harbour relictual faunas from periods in the past when the climate was cooler. This is particularly relevant in the BMTA, since eastern Tasmania is generally dry, and relict species are likely to occur only in isolated areas where they have survived the drying climate. There was a high level of local endemism found for this site (11%), even compared to a sample from 200 m lower down in the same catchment (site 9). The results suggest that such streams should be afforded protection in their own right. In the BMTA, the main threats to these streams and their fauna include logging and other forestry activity (see below).

The slow-flowing lowland portion of Pepper Creek (site 7) contained the highest species richness, and was also found to contain four of the invertebrate species which are important from a conservation viewpoint and eleven species which were not found elsewhere (table 3). The high species richness at this site may be a function of habitat diversity (since it contained logs and rocks on the creek bed, also macrophytic vegetation, and was fed by a flowing creek). These microhabitats present excellent areas for predator avoidance (see below).

### Introduced Fish

Eight freshwater fish species have been recorded for the BMTA and, of these, four are non-native (brown and rainbow trout, redfin perch and tench; Hepper de Gryse Team 1991). Brown trout were recorded from sites 6, 7, 8 and 9 in this study. The feeding habits of introduced fish species represent a threat to native invertebrate assemblages and also to other native fish species. For instance, brown trout are considered to represent the most serious threat to the continued survival of the swan galaxiid (Sanger & Fulton 1991). Brown trout in Victoria have been shown to feed selectively on native galaxiid species until the prey numbers drop, after which they feed on selected invertebrate groups, changing the

proportional representation of these in the community (Fletcher 1986). Research into the effects of trout on invertebrates in Tasmanian waterways has not been undertaken, despite numerous demonstrations that trout feed on important species, and repeated calls for the research to be done (see Horwitz 1990).

The high proportion of introduced fish in the BMTA (4 out of 8 species present) has undoubtedly already affected the nature of the faunal assemblages in the area. The disturbance to native freshwater communities by trout is probably the most serious alteration to the freshwater fauna in the BMTA since the Europeanisation of Tasmania.

### Other Threats to Freshwater Fauna

The BMTA is subjected to a number of activities which have the potential to degrade freshwater habitats, in particular forestry, grazing and military operations.

Uncontrolled forestry activity has the potential to alter the composition of freshwater faunal assemblages by changing the hydrology, increasing sediment and nutrient loads, changing temperature regimes and energy inputs, channelising and altering the extent of woody material in water courses (Taylor 1990). The Draft Forest Practices Code (Forestry Commission of Tasmania 1989) should operate to minimise these and other impacts resulting from forestry activity.

In the BMTA, the issues of steep-country logging and logging in upland areas require consideration beyond those given in the Code as far as the freshwater fauna are concerned. Temporary creeks and pools in upland areas were found to contain elements of fauna which require protection. These habitats are generally classified as "Class 4 streams" by the Code and are given scant protection, resulting in the impacts outlined above. No riparian reserves are required, the only restriction being "no logging machinery within 10 m of the streambank except at defined crossing points" (Forestry Commission of Tasmania 1989: 35).

The extent of grazing in the BMTA should also be restricted, as grazing can affect waterways and the fauna in them by removing riparian vegetation, increasing nutrient loads, causing stream-bank erosion and increasing sediment input, thus potentially smothering benthic fauna, particularly those which rely on filter feeding mechanisms.

Military operations in the BMTA have the same potential to detrimentally affect freshwater faunas by physically and mechanically disturbing drainage lines, or creek and river beds and banks. The placing of explosives into waterways during military training activities obviously needs to be restricted, given that it is undoubtedly lethal to elements of the freshwater fauna (in particular fish, but it is also highly probable that frogs and invertebrates are affected as well).

### ACKNOWLEDGEMENTS

The study formed part of a multidisciplinary assessment of the BMTA, which involved 18 specialist consultants representing over 15 professional disciplines, undertaken as part of an environmental impact assessment for the Department of Defence.

Identifications were made according to available keys for each group, except for selected groups (Hydrobiidae, Ephemeroptera, Phreaticoidea and Acarina), which were

identified by biologists familiar with them (Winston Ponder, Stuart Chilcott, Brenton Knott and Mark Harvey respectively). The identifications determined for the Odonata were verified by Piers Allbrook. Andrew Gibbons provided mounted slides of chironomid material.

## REFERENCES

- ALLBROOK, P., 1979: *TASMANIAN ODONATA. Fauna of Tasmania Handbook* no. 1, University of Tasmania.
- BLAKE, G.M., 1991: The effects of habitat age and other factors on the structure of the pelagic community in some farm dams in Tasmania. Unpubl. B.Sc. Hons thesis, Univ. Tasm.
- BENNISON, G.L., 1975: An ecological method of classification of the Coal River in south-east Tasmania. Unpubl. B.Sc. Hons thesis, Univ. Tasm.
- FLETCHER, A.R., 1986: Effects of introduced fish in Australia. In de Deckker, P. and Williams, W.D. (Eds): *LIMNOLOGY IN AUSTRALIA*: 231-238.
- FORESTRY COMMISSION, TASMANIA, 1989: *DRAFT FOREST PRACTICES CODE*. Forestry Commission, Hobart, Tasmania.
- GREENSLADE, P., in press: *CONSERVATION PRIORITIES FOR TASMANIAN NON-MARINE INVERTEBRATES*. Australian National Parks and Wildlife Service, Canberra, Australia.
- HEPPER DE GRUYSE TEAM, 1991: *ENVIRONMENTAL IMPACT ASSESSMENT, BUCKLAND TRAINING AREA — AUSTRALIAN ARMY*. 6th Military District, Hobart, Tasmania.
- HORWITZ, P., 1990: *CONSERVATION STATUS OF AUSTRALIAN FRESHWATER CRUSTACEANS*. Australian National Parks and Wildlife Service Report Series 14. Canberra, Australia.
- SAMWAYS, M.J., 1989: Farm dams as nature reserves for dragonflies (*Odonata*) at various altitudes in the Natal Drakensburg Mountains, South Africa. *Biol. Conserv.* 48: 181-188.
- SANGER, A. & FULTON, W., 1991: Conservation of endangered species of Tasmanian freshwater fish. Inland Fisheries Commission Occasional Report 91-01. Unpublished report, Hobart, Tasmania.
- TAYLOR, R., 1990: *FOREST PRACTICES FAUNA MANUAL*. Forestry Commission, Tasmania.
- WALKER, W. G., 1974: An investigation of farm dams in the Copping area of Tasmania. Unpubl. B.Sc. Hons thesis, Univ. Tasm.
- WATTS, C.H.S., 1978: A revision of the Australian Dytiscidae (Coleoptera). *Aust. J. Zool. Suppl. Ser.* 57: 1-166.
- WELLS, S.M., PYLE, R.M. & COLLINS, N.M. (Eds.), 1983: *THE IUCN INVERTEBRATE RED DATA BOOK*. International Union for the Conservation of Nature, Gland, Switzerland.

(accepted 18 September 1992)

## A DESCRIPTIVE CATALOGUE OF THE TYPE MATERIAL (CHORDATES) IN THE TASMANIAN MUSEUM

by A.P. Andrews

ANDREWS, A.P., 1992 (31:x): A descriptive catalogue of the type material (chordates) in the Tasmanian Museum. *Pap. Proc. R. Soc. Tasm.* 126: 109–113. ISSN 0080–4703. Tasmanian Museum and Art Gallery, 40 Macquarie Street, Hobart, Tasmania, Australia 7000.

A classified list of the chordate type specimens, including references and collection data, is given together with notes on condition.

**Key Words:** chordates, types, catalogue, Tasmania.

### INTRODUCTION

A total of 87 type specimens of the Phylum Chordata is registered in the collections of the Tasmanian Museum and Art Gallery. This catalogue lists the types, together with the original name and reference. Subsequent changes in taxonomy are recorded where necessary. Also included are the collection data, where known with certainty, a brief description of each specimen and notes on the condition. The old registration numbers are included where applicable, together with those in current use (which should be cited).

The practice adopted by Andrews (1971) and Green (1974) of listing all available registered data is followed, irrespective of whether the specimens could be located at the time of writing.

### Phylum CHORDATA

#### Subphylum TUNICATA

##### Class ASCIDEACEA

#### Suborder STOLIDOBRANCHIA

##### Family PYURIDAE

Genus *Pyura* Molina, 1872

*Pyura tasmanensis* Kott, 1985

*Mem. Qld Mus.* 23, 1985: 331

Holotype: D1881, spirit specimen.

Paratypes: D1877 (7), spirit specimens.

Locality: Ralphs Bay Neck Canal, Tasmania, 15 Aug. 1938, R. Hetherington.

Note: The holotype and paratypes were selected from a sample originally registered as D720. Condition good.

#### Subphylum VERTEBRATA

##### Class ELASMOBRANCHII

##### Order SQUALIFORMES

##### Family SQUALIDAE

Genus *Centrina* Cuvier, 1816

*Centrina bruniensis* Ogilby, 1893

*Rec. Aust. Mus.* 2(5), 1893: 62

= *Oxynotus bruniensis* (Ogilby), 1893

Holotype: D154, dried mounted skin.

Locality: Bruny Island, Tasmania, date and collector unknown.

Note: Collected as a dead beach-washed specimen and is in a fair state of preservation. Old registration number TM3079.

#### Class TELEOSTOMI

##### Order CLUPEIFORMES

##### Family STERNOPTYCHIDAE

Genus *Polyipnus* Günther, 1887

*Polyipnus tridentifer* McCulloch, 1914

*Biol. Res. Endeavour* 2(3), 3 Jul. 1914: 87

Syntypes: D151 (5), spirit specimens.

Locality: Great Australian Bight, 800–900 m, 14 May 1913, FIS *Endeavour*.

Note: Some fin damage but otherwise in good condition.

Old registration number D37.

#### Order SALMONIFORMES

##### Family GALAXIIDAE

Genus *Galaxias* Cuvier, 1816

*Galaxias fontanus* Fulton, 1978

*Rec. Queen Vict. Mus.* 63: 1

Holotype: D1317, spirit specimen.

Paratypes: D1318–D1321 (4), spirit specimens.

Locality: Swan River, Tasmania, 22 Feb. 1978; W. Fulton and R. McDowall.

Note: Condition excellent.

*Galaxias parvus* Frankenberg, 1968

*Aust. Zool.* 14(3), 1968: 270

Holotype: D940, spirit specimen.

Locality: Lake Pedder, Tasmania, 1–3 Feb. 1967, R. Frankenberg.

Note: This species was described before the full size range was known, resulting in a juvenile being selected as the holotype. The size of adult *G. parvus* is given by Andrews (1976). Condition excellent.

*Galaxias pedderensis* Frankenberg, 1968

*Aust. Zool.* 14(3), 1968: 268

Holotype: D941, spirit specimen.

Locality: Lake Pedder, Tasmania, 1–3 Feb. 1967, R. Frankenberg.

Note: As the holotype is only 49 mm standard length, it is clearly a juvenile specimen. Adult *G. pedderensis* can attain a standard length of 97 mm (Andrews 1976). Condition excellent.

*Galaxias tanycephalus* Fulton, 1978  
*Aust. J. Mar. Freshw. Res.* 1978: 110

Holotype: D1266, spirit specimen.  
 Paratypes: D1267–D1269 (3), spirit specimens  
 Locality: Arthurs Lake, Tasmania, 7 Apr. 1976, W. Fulton.  
 Note: Condition excellent.

*Galaxias niger* Andrews, 1985  
*Pap. Proc. R. Soc. Tasm.* 119, 1985: 56

Holotype: D1926, spirit specimen.  
 Paratypes: D1927, D1928 (2), spirit specimens.  
 Locality: Reservoir Lakes, Tasmania, 21 Mar. 1984, P. Andrews.  
 Note: Fulton (1990), without justification, implied confusion between this species and *G. brevipinnis* Gunther. However, the two are clearly distinct and can be distinguished on meristic data alone. Dorsal fin rays in *G. niger* range from 8–10 with a mean of 9.2 from 20 counts, whereas *G. brevipinnis* ranged from 11–14 with a mean of 13.9 from 34 counts. Similarly, anal fin rays in *G. niger* ranged from 9–11 with a mean of 10.1 as against a range of 12–15, mean 13.9, in *G. brevipinnis*.

Other differences include the absence of enlarged lateral canine teeth in *G. niger*, together with the reduced pyloric caeca and the smaller paired fins. Condition excellent.

Genus *Paragalaxias* Scott, 1935  
*Paragalaxias shannonensis* Scott, 1935  
*Pap. Proc. R. Soc. Tasm.* 1935: 41  
 = *Paragalaxias dissimilis* Regan, 1905

Paratypes: D1, D996, spirit specimens.  
 Locality: Shannon River below Miena dam. Great Lake, Tasmania, 3 Dec. 1933, E.O.G. Scott.  
 Note: The second paratype, D996, was originally lodged with the Zoology Department, University of Tasmania, and was transferred to the Tasmanian Museum in 1969. Condition excellent.

*Paragalaxias eleotroides* McDowall and Fulton, 1978  
*Aust. J. Mar. Freshw. Res.* 29, 1978: 101

Holotype: D1259, spirit specimen.  
 Paratypes: D1261, D1262 (2), spirit specimens.  
 Locality: Great Lake, Tasmania, 3 May 1976, R. McDowall and W. Fulton.  
 Note: Condition excellent.

*Paragalaxias mesotes* McDowall & Fulton, 1978  
*Aust. J. Mar. Freshw. Res.* 29, 1978: 103

Holotype: D1260, spirit specimen.  
 Paratypes: D1263–D1265 (3), spirit specimens.  
 Locality: Arthurs Lake, Tasmania, 3 May 1976, R. McDowall and W. Fulton.  
 Note: Condition excellent.

*Paragalaxias julianus* McDowall and Fulton, 1978  
*Aust. J. Mar. Freshw. Res.* 29, 1978: 660

Holotype: D1327, spirit specimen.  
 Paratypes: D1328–D1331 (4), spirit specimens.  
 Locality: Julian Lakes, Tasmania, 25 Feb. 1978, R. McDowall and W. Fulton.  
 Note: Paratypes were taken from Lake Field and Lake Dudley which are part of the Julian Lakes complex. Condition excellent.

#### Order LOPHIIFORMES

##### Family ANTENNARIIDAE

Genus *Antennarius* Cuvier, 1816  
*Antennarius mitchelli* Morton, 1897  
*Pap. Proc. R. Soc. Tasm.* 1897: 98  
 = *Trichophryne mitchelli* (Morton), 1897

Holotype: D136, spirit specimen.  
 Locality: Lisdillon, east coast, Tasmania, 1895, Miss Mitchell.  
 Note: Old registration number TM3566 and TM5163. This specimen was apparently registered twice, in error, under the TM system. Condition good.

#### Order GADIFORMES

##### Family MORIDAE

Genus *Lepidion* Swainson, 1838  
*Lepidion microcephalus* Cowper, 1956  
*Pac. Sci.* 10: 407

Holotype: D160, spirit specimen.  
 Locality: East of Schouten Island, Tasmania, 15 Feb. 1953, T.R. Cowper.  
 Note: Some damage to the caudal fin and thoracic area but otherwise in fair condition.

##### Family MERLUCCIIDAE

Genus *Coryphaenoides* Hector, 1871  
*Coryphaenoides tasmaniae* Johnston 1883  
*Pap. Proc. R. Soc. Tasm.* 1883: 143  
 = *Macruronus novaezelandiae* (Hector), 1871

Holotype: D144, spirit specimen.  
 Paratypes: D31 (4), spirit specimens.  
 Locality: Kangaroo Bluff, Derwent River, Tasmania, date and collector unknown.  
 Note: Old registration numbers TM5785 (D144), TM5184 (D31). Condition fair.

Order BERYCIFORMES

Family BERYCIDAE

Genus *Austroberyx* McCulloch, 1911  
*Austroberyx brevis* (?) McCulloch, 1911  
*Biol. Res. Endeavour* 1, 22 Dec. 1911: 39  
 = *Centroberyx affinis* (Günther), 1859

Syntype: D139, spirit specimen.

Locality: Flinders Island, Bass Strait, 28 Aug. 1911, FIS *Endeavour*.

Note: Specimen labelled "*Austroberyx brevis* McCulloch, 1911, Cotype gen. et. sp.", McCulloch, however, makes no mention of this species in his description. Australian Museum number. E962. Condition good.

Family TRACHICHTHYIDAE

Genus *Hoplostethus* Cuv. and Val., 1829  
*Hoplostethus mediterraneus* C. & V. var. *latus*  
 McCulloch, 1914  
*Biol. Res. Endeavour* 2(3), 3 Jul. 1914: 97  
 = *Hoplostethus mediterraneus* Cuvier, 1829

Syntype: D140, spirit specimen.

Locality: Great Australian Bight, no collection date, FIS *Endeavour*.

Note: Old registration number D102, Australian Museum number E2467. Condition fair.

Order ZEIFORMES

Family Zeidae

Genus *Allocyttus* McCulloch, 1914  
*Allocyttus verrucosus* Gilchrist var. *propinquus*  
 McCulloch, 1914  
*Biol. Res. Endeavour* 2(3), 3 Jul. 1914: 116  
 = *Allocyttus verrucosus* (Gilchrist), 1906

Syntype: D146, spirit specimen.

Locality: Great Australian Bight, 14 May 1913, FIS *Endeavour*.

Note: Old registration number D32, Australian Museum number E3282. Condition good.

Order SYNGNATHIFORMES

Family SYNGNATHIDAE

Genus *Histogamphelus* McCulloch, 1914  
*Histogamphelus briggsii* McCulloch, 1914  
*Aust. Zool.* 1(1), 13 Jun. 1914: 29

Holotype: D141, spirit specimen.

Locality: Wineglass Bay, Tasmania, 13 Apr. 1914, E.A. Briggs.

Note: Old registration number D79. Condition fair.

Family MACRORHAMPHOSIDAE

Genus *Centriscoops* Gill, 1862

*Centriscoops cristatus* (?) McCulloch, 1914  
*Biol. Res. Endeavour* 2(3), 3 Jul. 1914: 93  
 = *Notopogon lilliei* Regan, 1914

Syntypes: D145 (2), spirit specimens.

Locality: Bass Strait, FIS *Endeavour*, collection date unknown.

Note: Name apparently introduced in error for *C. humerosus* McCulloch, 1911 = *N. lilliei* Regan (McCulloch 1914: 91). Old registration number D33, Australian Museum number E2145. This specimen could not be located at the time of writing.

Order SCORPAENIFORMES

Family PLATYCEPHALIDAE

Genus *Insidiator* Jordan and Snyder, 1900  
*Insidiator jugosus* McCulloch, 1914  
*Biol. Res. Endeavour* 2(3), 3 Jul. 1914: 144

Syntypes: D150 (2), spirit specimens.

Locality: Off Hummocky Island, Qld, 30 Jul. 1910, FIS *Endeavour*.

Note: Old registration number D36, Australian Museum number E2688. Condition good.

Order PERCIFORMES

Family CARANGIDAE

Genus *Caranx* Lacepede, 1802  
*Caranx humerosus* McCulloch, 1915  
*Biol. Res. Endeavour* 2, 21 Ap. 1915: 137  
 = *Carangoides humerosus* (McCulloch), 1915

Syntypes: D138 (2), spirit specimens.

Locality: Off Pine Peak, Qld, 1 Aug. 1910, FIS *Endeavour*.

Note: Old registration numbers D100, D101. Australian Museum number E2821. Condition good.

Family EMMELICHTHYIDAE

Genus *Plagiogeneion* Forbes, 1890

*Plagiogeneion macrolepis* McCulloch, 1914  
*Biol. Res. Endeavour* 2(3), 3 Jul. 1914: 104

Syntypes: D148, D149 (2), spirit specimens.

Locality: Great Australian Bight, FIS *Endeavour*, collection date unknown.

Note: Old registration numbers D34 (D148), D35 (D149). Australian Museum numbers E2329 (D148), E2333 (D149). Condition good.

Family PEMPHERIDAE

Genus *Pempheris* Cuvier, 1829

*Pempheris elongata* McCulloch, 1911

*Biol. Res. Endeavour* 1, 22 Dec. 1911: 47

= *Parapriacanthus elongatus* (McCulloch), 1911

Syntype: D137, spirit specimen.

Locality: Flinders Island, Bass Strait, 28 Aug. 1911, FIS Endeavour.

Note: Australian Museum number E70. Some damage to the lower jaw, condition otherwise good.

Family ODACIDAE

Genus *Olistops* Richardson, 1850

*Olistops brownii* Johnston, 1884

*Pap. Proc. R. Soc. Tasm.* 1884: viii and 193

= *Odax cyanomelas* (Richardson), 1850

Holotype: D135, spirit specimen.

Locality: Table Cape, Tasmania, Mr I. Brown, collection date unknown.

Note: Condition fair.

Family TRIPTERYGIIDAE

Genus *Forsterygion* Whitley and Phillips, 1939

*Forsterygion gymnotum* Scott, 1977

*Pap. Proc. R. Soc. Tasm.* 111: 158

Paratype: D1310, spirit specimen.

Locality: Montagu Bay, Derwent River, Tasmania, Aug. 1976, Mr T. Walker.

Note: Minor fin damage, condition otherwise fair.

Family GOBIIDAE

Genus *Gobius* Linnaeus, 1758

*Gobius hinsbyi* Johnston, 1903

*Pap. Proc. R. Soc. Tasm.*, abstracts, 13 May 1903: x, *nomen nudum*

= *Nesogobius hinsbyi* (McCulloch and Ogilby), 1919

Holotype: D142, spirit specimen.

Locality: Derwent River, Tasmania, Mr G. Hinsby, collection date unknown.

Note: Old registration number TM10934. Base of caudal fin broken, condition otherwise fair.

Family CLINIDAE

Genus *Clinus* Cuvier, 1816

*Clinus johnstoni* Saville-Kent, 1886

*Rep. Fish. Dep., Tasm.* 37, 1886: 13

= *Heteroclinus johnstoni* (Saville-Kent), 1886

Holotype: D58, spirit specimen.

Locality: Adventure Bay, Bruny Island, Tasmania, date and collector unknown.

Note: This specimen was listed as missing in 1953 and has not been found. The old registration number is given here.

Genus *Tasmanogobius* Scott, 1935

*Tasmanogobius gloveri* Hoese, 1991

*Mem. Mus. Vict.* 52(2): 364

Paratypes: D2052, D2053 (2), spirit specimens.

Locality: Green Island, southern Tasmania, 2 Jul. 1948, D.F. Turner.

Note: This type was selected from a sample originally registered as D589. Condition good.

*Tasmanogobius lasti* Hoese, 1991

*Mem. Mus. Vict.* 52(2): 366

Paratype: D2057, spirit specimen.

Locality: Derwent River, Tasmania, 7 Dec. 1960, D.F. Hoese.

Note: Condition fair.

Order PLEURONECTIFORMES

Family PLEURONECTIDAE

Genus *Taratretis* Last, 1978

*Taratretis derwentensis* Last, 1978

*Pap. Proc. R. Soc. Tasm.* 112: 23

Holotype: D1305, spirit specimen.

Paratype: D1332, spirit specimen.

Locality: Nutgrove Beach, Derwent River, Tasmania, 30 Mar. 1977, P.R. Last.

Note: Condition good.

Class REPTILIA

Order SQUAMATA

Family SCINCIDAE

Genus *Leiopisma* Dumeril and Bibron, 1839

*Leiopisma oocryptum* Hutchinson *et al.*, 1988

*Proc. R. Soc. Vict.* 100: 67

Holotype: C685, spirit specimen.

Paratypes: C657–C669, C670–C679, C684, C776 (23), spirit specimens.

Locality: Mt Eliza, southwestern Tasmania, 31 Jan. 1987, M. Hutchinson and T. Schwaner.

Note: Condition excellent.

Genus *Pseudemoia* Fuhn, 1967

*Pseudemoia palfreymani* Rawlinson, 1974

*Mem. Nat. Mus. Vict.* 35: 92

= *Leiopisma palfreymani* (Rawlinson), 1974

Paratypes: C106, C285, spirit specimens.

Locality: Pedra Branca Rock, Tasmania, Jan. 1956, A. Palfreyman.

Note: Specimen C106 was originally registered as Xa42 with the locality and date given in error as "Arve Valley, Tasmania, January 1957". The same date was listed for C285 but with the locality and collector correct. Internal condition of both specimens is poor due to dehydration after death and C106 is missing part of the tail.

Class AVES  
 Order PASSERIFORMES  
 Family MELIPHAGIDAE  
 Genus *Melithreptus* Vieillot, 1816  
*Melithreptus affinis* (Lesson), 1839  
*Rev. Zool.* 1839: 167

Type (?): B1252, three eggs.

Locality: Bridgewater, Tasmania, 17 Nov. 1884, Miss A. Brent.

Note: This clutch of three eggs has been labelled "type specimen" since it was received in 1884. Being the first eggs collected of the species, a detailed description was published by Campbell (1900). Although Campbell did not refer to a type, a number of early authors described specimens, which have subsequently been regarded as types, without having been designated as such by the authors.

According to the *International Code of Zoological Nomenclature*, descriptions based on parts of animals can have type status if the descriptions were published prior to 1931.

However as Lesson's description was published in 1839, the type status is dubious and is included here merely for the sake of completeness.

Class MAMMALIA  
 Subclass EUTHERIA  
 Order PINNIPEDIA  
 Family OTARIIDAE  
 Genus *Arctocephalus* Cuvier, 1824  
*Arctocephalus tasmanicus* Lord and Scott, 1926  
*Pap. Proc. R. Soc. Tasm.* 1926: 189  
 = *Arctocephalus pusillus* (Schreber), 1776

Syntypes: 1, A808 cranium and mandible; 2, A809 cranium; 3, A810 cranium; 6, A806 cranium; 9, A807 cranium.

Localities: A808–A810, Councillor Rock, Clarke Island, Bass Strait, Aug. 1925, collector unknown. A806, North Bay, Tasman Peninsula, Tasmania, C. Lord, collection date unknown. A807, Bicheno, Tasmania, C. Lord, May 1925.

Note: Lord & Scott (1926) based their description on a series of syntypes numbered 1–10. Skins were originally associated with A808, A809 and A810 but these could not be located at the time of writing. The above specimens are all damaged. A808 and A809 are missing the rear section of the braincase, A810 has a bullet hole through the braincase, A806 and A807 are missing the teeth. Old registration numbers D751 (A808), D752 (A809), D753 (A810), D737 (A806), D746 (A807). Syntype numbers 4, 5, 7, 8 and 10 are held by the Queen Victoria Museum and Art Gallery, Launceston (see Green 1974).

## REFERENCES

- ANDREWS, A.P., 1971: A catalogue of the type material (fishes) in the Tasmanian Museum. *Pap. Proc. R. Soc. Tasm.* 105: 1–3.  
 ANDREWS, A.P., 1976: A revision of the Family Galaxiidae (Pisces) in Tasmania. *Aust. J. Mar. Freshw. Res.* 27: 297–349.  
 CAMPBELL, A.J., 1900: *NESTS AND EGGS OF AUSTRALIAN BIRDS*. Pawson and Brailsford, Sheffield: 366 pp.  
 FULTON, W., 1990: *TASMANIAN FRESHWATER FISHES. Fauna of Tasmania Handbook 7*. University of Tasmania, Hobart: 80 pp.  
 GREEN, R.H., 1974: A catalogue of the type material in the Queen Victoria Museum, Launceston. *Rec. Q. Vict. Mus.* 52: 1–15.  
 LORD, C. & SCOTT, H.H., 1926: Studies in Tasmanian mammals, living and extinct, 4, the eared seals of Tasmania, 2. *Pap. Proc. R. Soc. Tasm.*: 187–194.  
 MCCULLOCH, A.R., 1914: Report on some fishes obtained by the FIS *Endeavour* on the coasts of Queensland, New South Wales, Victoria, Tasmania, South Australia and South Western Australia. *Biol. Res. Endeavour* 2(3): 77–165.

(accepted 7 February 1992)



# MORPHOLOGY, ECOLOGY AND DISTRIBUTION OF *ISOETES* L. IN TASMANIA

by Michael Garrett and Gintaras Kantvilas

(with one table and seven text-figures)

GARRETT, M. & KANTVILAS, G., 1992 (31:x): Morphology, ecology and distribution of *Isoetes* L. in Tasmania. *Pap. Proc. R. Soc. Tasm.* 126: 115–122. PO Box 49, Bicheno, Tasmania, Australia 7215 (MG); and Tasmanian Herbarium, GPO Box 252C, Hobart, Tasmania, Australia 7001 (GK).

Five species of *Isoetes* are known in Tasmania. *I. elatior*, *I. humilior* and *I. gunnii* are endemic, whilst *I. drummondii* and *I. muelleri* are also widespread in mainland Australia. Distinguishing morphological characteristics, distribution and ecology of the species are discussed. *I. muelleri* is much more common and widespread than originally thought, and many new records have been made for *I. drummondii*, *I. elatior* and *I. humilior*, enabling a better understanding of the ecology and conservation status of the genus in Tasmania.

**Key Words:** *Isoetes*, Pteridophytes, Tasmania, fern allies, endemic.

## INTRODUCTION

*Isoetes*, a genus of the fern allies, consists of some 130 species (Jermy 1990) and is widely distributed in temperate and tropical regions of the world (Hall 1971, Mickel 1979). It is the sole genus of the family Isoetaceae within the class Lycopsidea, and is comprised of the subgenera *Isoetes*, *Stylites* and *Euphyllum* (Hickey 1990). Its closest living relatives include *Lycopodium*, *Phylloglossum* and *Selaginella*.

In the Australasian region, *Isoetes* exhibits a large degree of localised endemism. All five species known from Papua New Guinea are endemic (Leach & Osborne 1985), as are the two New Zealand species (Brownsey & Smith-Dodsworth 1989). Fifteen species are known from Australia including Tasmania (R.J. Chinnock *in litt.*), of which six are confined to Western Australia (Johnson 1984), one each to the Northern Territory, South Australia and Victoria, and three to Tasmania. The genus thus shows a remarkable level of endemism in comparison to other pteridophytes in Tasmania, of which only five out of a total of approximately 100 species are endemic.

In Tasmania, *Isoetes* is represented by five species but, with the exception of the abundant and conspicuous *I. gunnii*, the genus has been poorly collected and data on its distribution are scant. A recent and ongoing survey of pteridophyte distribution in Tasmania has revealed that species of *Isoetes* in Tasmania are far more abundant than previously supposed. The present paper presents new information on their habitat, ecology, distribution and morphological characteristics.

## METHODS

Data are derived from the first author's field observations, and from the study of living material and dried herbarium specimens. Representative specimens are lodged in the Tasmanian Herbarium (HO).

Fieldwork was undertaken from December to April between 1989 and 1991. These months are regarded as the most conducive to collecting *Isoetes* in Tasmania: it is the time of lowest water levels and still, sunny days which make

possible the location and *in situ* study of the various species.

Distribution maps for the species are presented using a format consistent with Brown *et al.* (1983) for the Tasmanian endemic flora.

## GENERAL CHARACTERISTICS OF THE GENUS

### Morphology

*Isoetes* has a tuft of grass-like leaves arising from a greatly shortened axis, usually referred to as a corm. The corm may be two- or three-lobed in Australian species, although lobing can vary within the species (Marsden 1976) and may be difficult to determine. Consequently, this character is best avoided in differentiating the species. The corm is always buried deep in mud or amongst rocks, and the entire plant must be removed to determine its character. Numerous, thick, light to dark-brown roots arise from the furrows between the lobes, and are usually dichotomously branched towards their tips. Plants can occur as discrete individuals, often in colonies, or as a dense, continuous sward.

The sporophylls (referred to hereafter as leaves) are the visible part of the growing plant and, together with the corm, may be buried for over half their length in the substrate. They are basically cylindrical, but flattened on their adaxial side from the base for part of their length. Depending upon the species, leaves may vary from thin and flaccid to thick and rigid. Their colour is generally light to dark green, with the buried section white or brown. Numerous pale or white transverse septa that partition internal air chambers are clearly visible on the leaves of most species. New leaves arise from the centre of the plant. All are abruptly widened at their bases, where they sheath the corm apex and produce a swollen base to the plant. The presence of basal sporangia further accentuates the bulbous appearance of the plant.

Single large sporangia occur on the adaxial side of the broadened leaf bases, virtually on every leaf of a mature plant. Their size and shape varies within a single species, ranging from orbicular to elliptical and from 2–10 mm

wide. Megasporangia and microsporangia are superficially identical. They may be naked, dark brown to black and very conspicuous when mature, or completely (or rarely partially) covered by a velum. In the latter case, the dark spore mass is usually just visible through the velum. In most species, the spore mass is also usually just visible through the abaxial side of the leaf base. Megaspores are white or grey, very large (up to 750 µm in *I. muelleri* Marsden 1976) and individually easily visible to the naked eye. Megaspore ornamentation varies between species and is best viewed when megaspores are dry. Microspores are dark brown in mass when wet and are only visible to the naked eye in mass. Morphological characters of the Tasmanian species are summarised in table 1.

Interspecific hybridisation amongst overseas populations of *Isoetes* is well documented (Hickey *et al.* 1989, Jermy 1990) but to date, no hybrids have been recorded in Tasmanian populations.

Habitat

In Tasmania, *Isoetes* is an aquatic or, less commonly, semi-aquatic plant of fresh water. It grows predominantly in mud or silt in the still or slow-moving waters of rivers and lakes, especially in expanses of flat land such as the Central Plateau and Midlands, or broad river systems such as the Derwent and Fingal Valleys. Occasionally, it may occur also in faster flowing sections of rivers with relatively silt-free beds. The habitat of the Tasmanian species is summarised in table 1.

KEY TO ISOETES SPECIES IN TASMANIA

- 1. Sporangium wholly (or rarely partially) covered by a velum ..... 2  
Sporangium lacking a velum ..... 3
- 2. Leaves rigid and erect. Megaspores and microspores present. Plant of alpine and sub-alpine areas only ..... 4. *I. humilior*  
Leaves flexible. Megaspores only present.  
Plant of lowland to alpine altitudes ..... 5. *I. muelleri*
- 3. Leaves rigid and erect, 2–5 mm thick in mid-section. Plant of alpine and sub-alpine areas only ..... 3. *I. gunnii*  
Leaves soft and flexible, 1–2 mm thick in mid-section ..... 4
- 4. Leaves to 0.12 m long. Plant of still, shallow water or drying mud, ranging from lowland to alpine altitudes ..... 1. *I. drummondii*  
Leaves 0.25–0.7 m long. Plant of permanent, running water in lowland rivers ..... 2. *I. elatior*

1. *Isoetes drummondii* A. Braun

Monatsber. K. Akad. Wiss. Berlin 573 (1863)

Diagnostic Characters (Fig. 1E)

Plants single or in colonies. Corm 2- or 3-lobed. Leaves usually spreading, sometimes erect if in deep water, devoid of algae or silt build-up, bright green (except for a pale or white

buried basal section), flexible and slender, gradually tapering to a point, to 0.12 m long (usually c. 75 mm) and 1.5 mm wide in middle section, very noticeably flattened on the adaxial side for most of their length. Sporangia naked, both megasporangia and microsporangia present. Megaspores finely tuberculate.

Notes

*I. drummondii* is best recognised by its spreading habit, clean, green, markedly flattened leaves, and its habitat (see below). The freshness of its leaves suggests that old leaves may be shed each season. In general, the species tends to have very exaggerated, swollen leaf bases, particularly when growing in drier sites, suggesting that this may be a mechanism for protection or food storage through periods of drought.

Distribution

This species appears to be uncommon in Tasmania. It is known from scattered localities on the Central Plateau between 900 and 1020 m above sea level, such as Wihareja Lagoon, Ripple Creek, Camerons Lagoon and Shannon Lagoon. It is locally frequent on the shores of Lake Leake (600 m) on the central east coast, and nearby at Ladies Mile Marsh. There is a small population on the lower Apsley River, 4 km southwest of Bicheno. It is also rare in a small lagoon south of Cleveland in the Midlands, and was collected near Georgetown by W.M. Curtis (fig. 3). The species is also known from all Australian states except the Northern Territory (R.J. Chinnock *in litt.*).

Habitat and Ecology

*I. drummondii* grows in mud in shallow, still waters, or at their seasonally dry margins, and is as equally abundant in man-made water channels and waterholes as in natural sites. However, its requirement for a permanent covering of water is not as critical as for most other Tasmanian species of *Isoetes*. For example, in midsummer in Hortons Creek at Stonehouse Bridge, Ladies Mile Marsh, some plants occur in mud to a depth of 0.15 m below the water surface, but most grow in drying sections of man-made ditches and the creek, buried deep in moist, muddy clay. The leaves of plants farthest from water were starting to wilt and decay. Elsewhere in the area, *I. drummondii* hardly behaves as an aquatic at all, with robust plants growing amongst a dense sward of grasses and herbs in moist soil, the majority being grazed back to the rootstock by animals.

In most other sites in Tasmania, *I. drummondii* occurs with little, if any, competition from other plants. Although generally preferring shallower water, it often grows with *I. muelleri*, e.g. along the rocky shores of Lake Leake, a superficially unusual habit, where the species colonises the silt and mud amongst the rocks.

Selected specimens examined

TASMANIA: Roadside soak between Epping Forest and Conara, 200m, W.M. Curtis 22.xii.1955 (HO 126571). Road to aerodrome [Georgetown], W.M. Curtis 19.xii.1955 (HO 25248). Stonehouse Bridge, Lake Leake Road, 610m, M. Garrett 13.xii.1990 (HO 126392). Cider Marsh, 860m, W.M. Curtis 11.i.1970 (HO 114702).

2. *Isoetes elatior* F. Muell. ex A. Braun  
*Linnaea*: 25: 722 (1852)

Diagnostic Characters (figs 1A, 2A)

Plant single or in colonies. Corm 3-lobed. Leaves erect (in still water) or often swept sideways (in running water), clean or with dense build-up of algae or silt, light green except for a pale or white, buried basal section, very thin and flaccid, to 0.70 m long (usually c. 0.25–0.30 m) and 2 mm wide in middle section, distinctly flattened on the adaxial side for at least half their length. Sporangia naked, both megasporangia and microsporangia present. Megaspores finely tuberculate.

Notes

*I. elatior* is one of the largest species of the genus in Australia, rivalled in size only by the northern Australian species *I. coromandelina*. Leaf width of both large and small plants tends to be much the same and consequently the latter can be practically identical with *I. muelleri*, especially when both species co-occur and are covered with algae. However, *I. elatior* is easily recognised by the absence of a velum, with large

plants also possessing very noticeable membranous marginal flaps which extend up the leaf to 0.10 m beyond the broadened leaf base.

*I. elatior* can also be confused with *I. drummondii*, but the two species grow in entirely different habitats and are unlikely to be found together. They occur 3 km apart on the Apsley River, but under different conditions. Nevertheless, an exceptionally tall specimen of *I. drummondii* from South Australia was mis-identified as *I. elatior* in the past (Duncan & Isaac 1986).

Distribution

*I. elatior* is endemic to Tasmania and appears to be the rarest of the species. It is also the only one restricted to the lowlands. The species was originally described from an unknown location on the South Esk River, and an adrift plant has since been collected from the Lake River at Longford by D.I. Morris. During the present survey, it was recorded from the South Esk River near Avoca and Fingal, at a number of sites on the St Pauls River, from the Break O'Day River, and in the lower reaches of the Apsley River (fig. 4). These collections

Table 1  
Morphology and habitat of *Isoetes* in Tasmania

|                                   | <i>I. muelleri</i>                       | <i>I. humilior</i>             | <i>I. elatior</i>           | <i>I. drummondii</i>                     | <i>I. gunnii</i>               |
|-----------------------------------|------------------------------------------|--------------------------------|-----------------------------|------------------------------------------|--------------------------------|
| Velum                             | present                                  | present                        | absent                      | absent                                   | absent                         |
| Spores                            | megaspores                               | megaspores<br>& microspores    | megaspores<br>& microspores | megaspores<br>& microspores              | megaspores<br>& microspores    |
| Megaspore ornamentation           | nearly smooth, tuberculate or reticulate | smooth or sparsely tuberculate | finely tuberculate          | finely tuberculate                       | smooth or sparsely tuberculate |
| Corm lobing                       | 2–3                                      | 2 (rarely 3)                   | 3                           | 2–3                                      | 3                              |
| Plant habit                       | spreading or upright                     | upright                        | swept sideways or upright   | spreading                                | upright                        |
| Max. leaf length                  | 400 mm                                   | 100 mm                         | 700 mm                      | 120 mm                                   | 200 mm                         |
| Mean leaf length                  | 100 mm                                   | 75 mm                          | 300 mm                      | 75 mm                                    | 100 mm                         |
| Max. mid-leaf thickness           | 2.5 mm                                   | 3 mm                           | 2 mm                        | 1.5 mm                                   | 5 mm                           |
| Habitat                           | rivers & lakes                           | rivers (& lakes?)              | rivers                      | drying margins of rivers, lakes & swamps | lakes, tarns & rivers          |
| Altitudinal range                 | 20–1140 m                                | 860–1180 m                     | 20–220 m                    | 20–1020 m                                | 540–1360 m                     |
| Population habit                  | single plants                            | single plants or swards        | single plants               | single plants                            | single plants or swards        |
| Water flow                        | still to moderately running              | (still?) to moderately running | moderately to fast running  | still                                    | still to moderately running    |
| Comparative summer water coverage | exposed or covered                       | mostly covered                 | covered                     | mostly exposed                           | mostly covered                 |

represent the first *in situ* gatherings of the species in more than 150 years.

#### Habitat and Ecology

*I. elatior* grows usually in moderate to fast-flowing water, typically in a mixture of rock, gravel and silt, or in almost pure coarse sand. An exception was a site on the South Esk River, where the largest specimens seen (0.7 m tall) were growing in thick mud. The species requires a year-round permanent covering of water. For example, even in mid-March when water levels are extremely low, a few small plants were observed in 0.1 m of water, the majority at a depth of 0.3 m, and some as deep as 0.7 m. Whilst the leaves of other species (even those of *I. muelleri* and *I. drummondii*) remain upright above the water surface when emergent, those of *I. elatior* lie flat against the surface.

In the South Esk, St Pauls and Break O'Day Rivers, *I. elatior* grows mostly with *I. muelleri*, with the latter usually in stiller water, and the former in deeper and faster flowing water. Perhaps because of its ultimately large size, *I. elatior* also appears to be more capable of resisting competition from other larger aquatic plants, such as *Triglochin procera*.

Little remains of the natural vegetation at *I. elatior* localities in the South Esk River. Several serve as watering holes for stock which feed on the surrounding flats, and the river banks support scattered willows (*Salix alba*) and abundant gorse (*Ulex europaeus*). The *Isoetes elatior* plants at these sites are rather remarkable in their large size, with most having leaves 0.40 m or more in length. The larger plants also have thick bulbous bases with diameters of 40–50 mm, caused by the profusion of leaves, up to 60 or 70 per plant.

Localities in the St Pauls and Apsley Rivers are fringed by *Callitris oblonga* and species of *Leptospermum*. Here the leaves of *I. elatior* rarely attain 0.4 m in length, with an average of 0.2–0.3 m, possibly because of the shallower water flow. It is possible but unlikely that larger specimens grow in the numerous, deep, still sections of the Apsley River; the water there is always murky but even at low water levels, plants have not been seen. Overall, the Apsley River seems somewhat atypical for *I. elatior*. The river has very little water flow during the summer months, *I. muelleri* does not appear to occur there, and *I. elatior* has been found only in a 4 km section a few metres above sea level and 5 km from the sea. It has not been located in the remainder of the relatively flat and open section of the river between there and Apsley Gorge, and is unlikely to occur in the shallow waters of its catchment area.

#### Selected specimens examined

TASMANIA: Apsley River, M. Garrett 17.v.1990 (HO 126026). Adrift in Lake River at Longford, D.I. Morris 8.xi.1978. (HO 28160). South Esk River, 200m, M. Garrett 10.iv.1990 (HO 125862).

### 3. *Isoetes gunnii* A. Braun

*Monatsber. K. Akad. Wiss. Berlin* 535 (1868)

#### Diagnostic Characters (figs 1B, 2C)

Plants single or in colonies, or occurring as dense swards of dwarfed individuals. Corm 3-lobed. Leaves erect, dark green except for the white to brown-tinged basal section, very thick and rigid, to 0.2 m long and 5 mm thick in middle section,  $\pm$  flattened on the adaxial side for half their length. Sporangia large, naked and prominent, both megasporangia and microsporangia present. Megaspores smooth or sparsely tuberculate.

#### Notes

*I. gunnii* can be distinguished from other Tasmanian species by its large, robust habit and by its naked sporangia.

#### Distribution

*I. gunnii* is endemic to Tasmania. It is widespread in alpine and sub-alpine areas of Tasmania, on quartzite, dolerite and sedimentary soils, ranging from Reservoir Lakes in the far south to Paddys Lake in the north, and Lakes Youl and Baker on Ben Lomond in the northeast (fig. 5). It is likely to be present in the majority of natural highland lakes and tarns.

#### Habitat and Ecology

*I. gunnii* is common in highland lakes and tarns, where it is often the sole conspicuous aquatic plant. In some shallow lakes, it can be so abundant that accumulated floating debris seems to be composed solely of its leaves, sometimes providing the only indication of the presence of the species. Whole plants or clumps of plants may also be washed ashore, probably dislodged by water birds or wave action. The

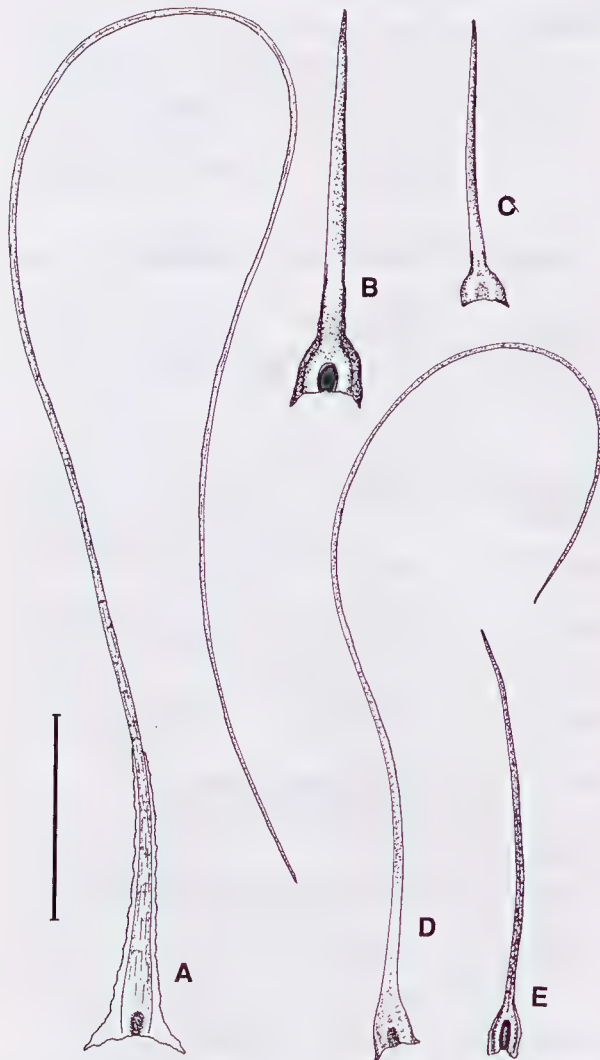


FIG. 1 — Sporophylls of Tasmanian *Isoetes* species: (A) *I. elatior*; (B) *I. gunnii*; (C) *I. humilior*; (D) *I. muelleri*; (E) *I. drummondii*. Scale = 50 mm.

species does not appear to extend beyond depths of 1–1.5 m, and in deep lakes (e.g. Lake Perry, Hartz Mountains National Park), it only fringes the shoreline. Whilst tightly packed clumps of perhaps hundreds of plants occur in rocky shallows, the largest, most robust plants, often occurring individually, are found in thick mud and silt, often with only the top third visible above the substrate. Germinating sporangia in leaf axils have been observed in small loose clumps of plants and presumably in this manner, more dense clusters are developed.

Plants in exceptionally small, shallow tarns may be completely yellow or blackened, possibly due to increased or fluctuating water temperatures. Stunted plants in very shallow water can be exposed during summer months, but seldom by more than a few centimetres above water level (never as much as *I. muelleri* or *I. drummondii*) and survive by being buried deep in mud, amongst rocks or within the protection of large clumps. Exposed plants, freshly grazed back to the rootstock, have also been observed, suggesting the species may be palatable to native animals.

*I. gunnii* is less common in running water, although quite large specimens occur in calmer areas of silt build-up, while smaller or clump-forming plants are found in quicker flowing water and rockier sections. Colonies of both large and small plants have been observed in the slow moving sections of the Little Pine River and the uppermost parts of the Derwent River, as well as in the Nive River and Pine Tree Rivulet.

In the Central Plateau area, *I. gunnii* often grows with *I. muelleri*, with the former dominant and favouring deeper water. In the Ouse and Little Pine Rivers, populations of *I. gunnii* and *I. humilior* grow side by side, often intermingled in the same clumps, and here the extent to which these two species are vegetatively similar is most apparent. At Fergies Paddock on the southwestern shore of Lake St Clair, and in the Little Pine River, *Pilularia novae-hollandiae* also occurs with *I. gunnii*, its rhizome often creeping amongst the leaves of *Isoetes*.

*I. gunnii* does not appear to be as successful as either *I. muelleri* or *I. drummondii* in re-establishing itself in artificial waters. However, it is quite common at the northern end of St Clair Lagoon, and has also established in what appears to be a constructed canal connecting the lagoon to Lake St Clair at the pumping station. HEC work at this site was completed in 1935 (J. Linton, pers. comm.), and it would seem that *I. gunnii* requires at least this length of time for re-establishment.

#### Selected specimens examined

TASMANIA: Milligans Peak, S.J. Jarman 28.i.1984 (HO 100595). Ladies Tarn, Hartz Mountains, 980 m, A.E. Orchard 11.ii.1980 (HO 33034). Lake Carly, 700 m, G. Kantvilas 8.ii.1985 (HO 89427), Lake Sydney, G. Kantvilas 17.xii.1982 (HO 74908).

#### 4. *Isoetes humilior* F. Muell. ex A. Braun *Linnaea* 25: 722 (1852)

#### Diagnostic Characters (figs 1C, 2B)

Plants single, in colonies, or more commonly in dense swards of dwarfed plants. Rootstock often not distinctly corm-like, but with 2 (rarely 3) very elongated lobes. Leaves erect, thick and rigid, dark green except for the white to brown-tinged basal section, to 0.1 m long and 3 mm thick in middle



FIG. 2 — Tasmanian endemic *Isoetes* species: (A) *I. elatior*; (B) *I. humilior*; (C) *I. gunnii*. Scale = 5 cm.

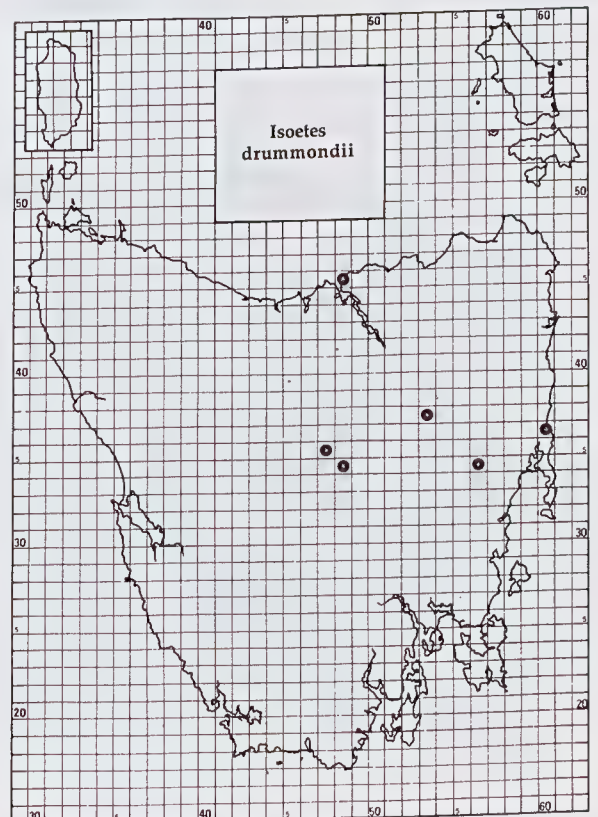
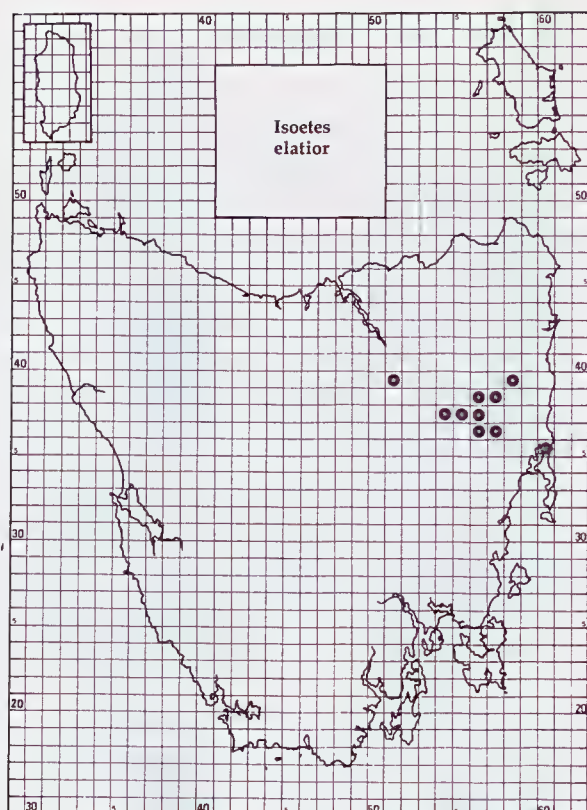
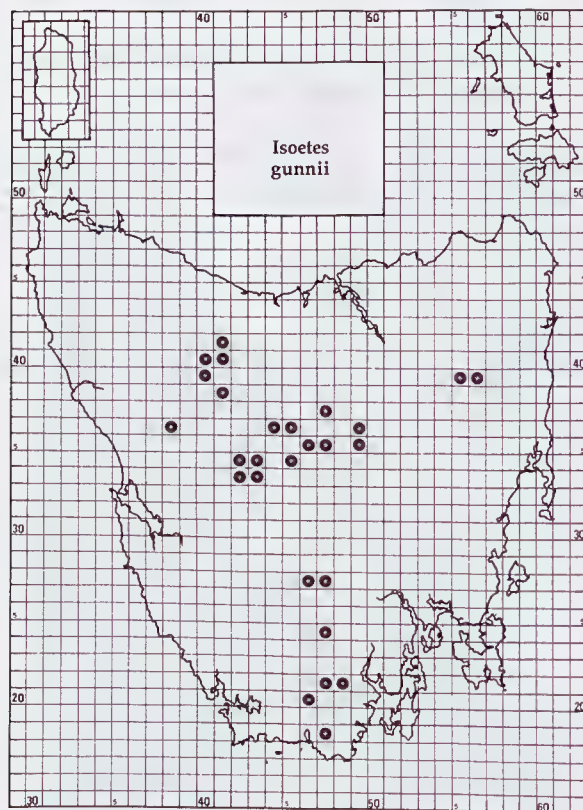


FIG. 3 — Distribution of *Isoetes drummondii* in Tasmania.

FIG. 4 — Distribution of *Isoetes elatior* in Tasmania.FIG. 5 — Distribution of *Isoetes gunnii* in Tasmania.

section, flattened on the adaxial side towards the base only. Sporangia completely (rarely partially) covered by a velum, both megasporangia and microsporangia present. Megaspores smooth or sparsely tuberculate.

#### Notes

In the field, *I. humilior* can be easily confused with *I. gunnii*, as both share the same habitat, growth habit, colour and leaf shape. On average, the leaves of *I. humilior* are shorter and thinner but nevertheless fall within the size range of those of *I. gunnii*, particularly when both species occur in communal clumps. However, *I. humilior* is distinguished by the presence of a velum covering the sporangia. Furthermore, its corm is usually bilobed, albeit rather indistinctly, whereas that of *I. gunnii* is distinctly tri-lobed. Sporangia covered by a velum are also found in the widespread and variable species, *I. muelleri*. Previous scant knowledge of *I. humilior*, and the misapplication of this name to forms of *I. muelleri* in the past, e.g. by Wakefield (1955) and Jones & Clemesha (1976), has led to some suggestion that the former is a hardened highland variant of the latter. However, the present survey indicated that *I. muelleri* always retains its characteristic soft foliage, even when growing with *I. humilior*, and is thus easily distinguishable in gross morphology. *I. humilior* can further be separated from *I. muelleri* by its elongated bi-lobed corm: although often bi-lobed, the corm of *I. muelleri* is distinctly rounded.

#### Distribution

*I. humilior* is endemic to Tasmania. During the present survey, it has been recorded only from the Central Plateau where it is occasional in the Ouse, Little Pine and Shannon Rivers. Dislodged plants have also been collected on the shores of Gunns Lake, Little Lake, Lake Fergus and St Clair Lagoon (fig. 6).

Whilst this distribution pattern, as well as the tough texture of its leaves, suggests that *I. humilior* is an alpine-subalpine species, it is interesting to note that Braun's type specimen (collected by Charles Stuart) is from the South Esk River. No collections of this species were made in this river system during the present survey and, despite supporting other species of *Isoetes* in its lower reaches, the river appears to lack suitable habitats for *I. humilior*. It is possible that Braun's type may have been a dislodged plant which entered the South Esk River via the streams which drain the northern parts of the Central Plateau.

#### Habitat and Ecology

The ecology of *I. humilior* remains poorly understood. It appears to have a preference for running water, especially shallow, slow-moving rivers, where it grows under similar conditions to those of *I. gunnii*. The largest plants are found in deeper, slower flowing water, while dwarfed communal clumps are more frequent amongst the cleaner rocky beds in fast currents. In February, when water levels are near or at their lowest, the majority of plants remain in 0.15 to 0.2 m of water, although some may have their tops emergent. However, completely exposed individuals are uncommon. Overall, *I. humilior* occurs as clumps more often than *I. gunnii*, and germinating sporelings within the clumps are common.

#### Selected specimens examined

TASMANIA: St Clair Lagoon, 737 m, M. Garrett 20.ii.1991 (HO 126563). Ouse River near Lake Augusta, 1160 m, M. Garrett 31.i.1990 (HO 125863).

5. *Isoetes muelleri* A. Braun  
*Monatsber. K. Akad. Wiss. Berlin* 541 (1868)

Diagnostic Characters (fig. 1D)

Plants single or in colonies. Corm 2- or 3-lobed. Leaves erect or spreading, light to dark green except for a pale or white buried basal section, flexible and slender, to 0.2(-0.4 m) long and 2.5 mm thick in middle section, flattened on the adaxial side for half the length. Sporangia completely (rarely partially) covered by a velum; only megasporangia present. Megaspores variable in size, shape and ornamentation, even within a single sporangium; ornamentation almost smooth, tuberculate or reticulate.

Notes

*I. muelleri* can be distinguished from the other Tasmanian species by the presence of a velum covering the sporangia, and by its soft leaves. No microspores have been observed in this species which appears to be strongly apomictic.

Some plants have extraordinarily enlarged corms, formed by the swollen sporangia bulging the abaxial side of the leaf base. This feature, also known in populations of *I. drummondii*, appears to be restricted to plants which must survive a prolonged period of relative dryness out of water. Individuals that are normally covered with algae when submerged tend to become smothered and flattened by the weight of the drying algae when the water level drops and the plant is exposed. Normally 'clean' plants have upright although slightly contorted leaves when exposed for some time. The plant's top growth dies back if the substrate becomes excessively dry.

Distribution

*I. muelleri* appears to be much more widespread than previously thought. It is most abundant in, but not confined to, the relatively flat land of the Central Plateau, Derwent Valley, Fingal Valley and Midlands, ranging from the Derwent River at New Norfolk in the southeast, to Lake St Clair in the west, Lake Trevallyn in the north, and to the Break O'Day and St Pauls Rivers in the east (fig. 7). It has a wide altitudinal range, from 20 m on the lower Derwent, to at least 1140 m at Second Lagoon on the Central Plateau. *I. muelleri* also occurs in all Australian states and territories (Marsden 1976).

Habitat and Ecology

*I. muelleri* occurs in the mud of shallow sections of rivers and lakes. It is usually submerged in at least 0.3-0.5 m of water for most of the year, with the largest plants occurring in deeper permanent water to a depth of 1.5 m, as for example, at the northern end of St Clair Lagoon. Such individuals can be difficult to locate because the whole plant, including new emerging leaves, is covered in a thick layer of algae and silt. In this condition, the species is easily overlooked. During the two to three months of summer, some plants may be exposed to 0.5 m above the water level. Such plants become sun-bleached yellow-green but remain quite healthy, growing in moist although not saturated mud.

The species is also known as a more-or-less free floating plant in fine silty mud, e.g. some metres from the shore in Penstock Lagoon, while in lakes such as Gunns Lake, Lake Sorell and Lake St Clair, it occurs in mud amongst rocks. In faster flowing sections of rivers, e.g. in the upper and lower Derwent River, Ouse River, Pine Tree Rivulet and Nive River, stunted plants may occur on the lee side of large rocks or in the sediment-filled cracks in rock platforms.

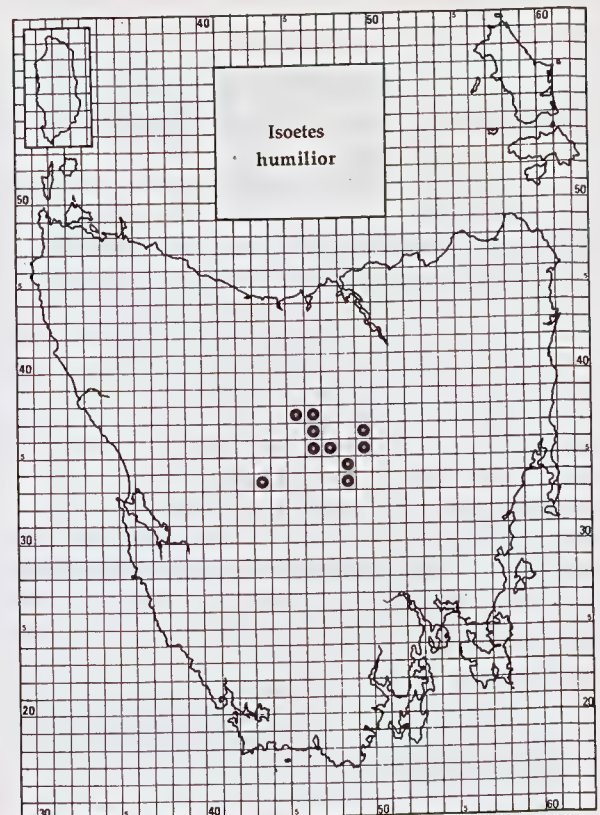


FIG. 6 — Distribution of *Isoetes humilior* in Tasmania.

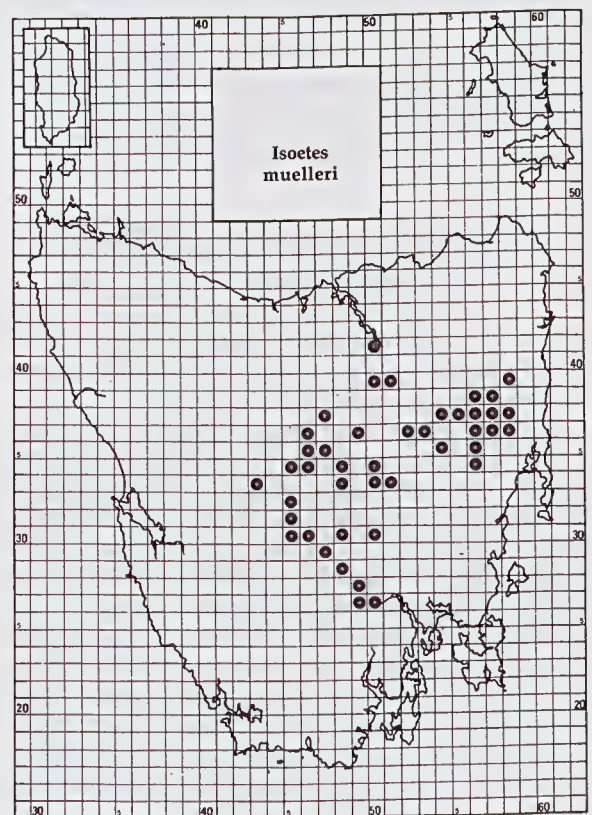


FIG. 7 — Distribution of *Isoetes muelleri* in Tasmania.

*I. muelleri* is most abundant at the wide, shallow margins of some highland lakes, particularly constructed impoundments such as Bronte Lagoon and Wayatinah Lagoon. These

waters all provide a large expanse of shallow water with a firm and slightly gravelly mud substrate, consolidated by other small aquatic plant species. The presence of larger plants, such as reeds, appears to be an important factor in the establishment and survival of *I. muelleri*, and may impede spore dispersal or produce conditions which are too shaded. Populations of *I. muelleri* are especially prolific on the eastern margins of these lakes, perhaps due to the dispersal by prevailing westerly winds of spores and whole plants dislodged by wave action, browsing waterfowl and fish. The origins of populations of *I. muelleri* in artificial waters requires further study. The species may have already been present in pre-dammed smaller lakes and marshes, or have spread from natural waters by the action of currents or waterfowl.

*I. muelleri* can be found growing with each of the other Tasmanian species of *Isoetes*. In the South Esk, Break O'Day and St Pauls Rivers, it occurs in still backwaters, close to *I. elatior*, which occurs in rockier and faster flowing water. In Lake Leake, Shannon Lagoon and Wihareja Lagoon, the species grows with *I. drummondii*, although in deeper water than that species. In Little Pine River, Pine Tree Rivulet, Gunns Lake, Nive River, Lake St Clair and the upper Derwent River, *I. muelleri* can co-occur with *I. gunnii* although there the former is usually found in shallower water. In the Shannon and Little Pine Rivers, it grows with *I. humilior*. The rare aquatic fern, *Pilularia novae-hollandiae*, may also be associated with *I. muelleri*.

#### Selected specimens examined

TASMANIA: St Pauls River at Avoca, 200 m, *M. Garrett* 10.iv.1990 (HO 125860). South Esk River, 8 km northeast of Avoca, 200 m, *M. Garrett* 10.iv.1990 (HO 125859). Elizabeth River, 200 m downstream of Lake Leake Dam, 560m, *M. Garrett* 27.iv.1990 (HO 125861). Macquarie River, 10 km west of Campbell Town, 160 m, *M. Garrett* 10.iv.1990 (HO 125857). Lake Sorell, Interlaken, 800 m, *D.I. Morris* 25.iv.1975 (HO 126585).

### CONSERVATION STATUS OF THE GENUS IN TASMANIA

Although none of the known populations of *Isoetes* in Tasmania appear to be under any immediate threat, not all the species are represented within reserves.

*I. drummondii* is at present unknown from any protected areas, although it occurs on the Central Plateau and further investigations may reveal populations within the World Heritage Area. Populations worthy of consideration for conservation exist at Wihareja Lagoon (where it occurs together with *I. muelleri* and *Pilularia novae-hollandiae*), and at Ladies Mile Marsh on the Eastern Tiers.

*I. elatior*, a Tasmanian endemic and one of the largest Australian species in the genus, is most in need of protection. It is completely unreserved, and all known populations are on private land. A private reserve (for *Callitris oblonga*) on the lower Apsley River is just downstream from the lowest known population of *I. elatior*, and it is highly unlikely that this species would occur far enough upstream to be within the Douglas-Apsley National Park. Unique problems are associated with the location of reserves for aquatic species. Riverbank reservation does not necessarily guarantee the protection of populations at that site, as influences from upstream activities are just as consequential for their survival. A combination of riverbank, upstream, and catchment reservation would seem desirable.

The endemic *I. gunnii* is common and widespread, and well protected in a number of reserves, including Mt Field National Park and the World Heritage Area.

While the exact distribution of the endemic *I. humilior* is unclear, populations on the Ouse River are also well inside the World Heritage Area.

*I. muelleri* is common and widespread, and well-reserved within the World Heritage Area. It has been overlooked in the past, and is likely to occur in other protected areas as well. This species appears to have been favoured by the formation of hydro-electric impoundments.

In general, most riverine habitats suitable for *Isoetes* (especially *I. muelleri* and *I. elatior*) also tend to be ideal for agriculture, and the native riverbank vegetation has usually been cleared to pasture, replaced by invasive introduced plants such as willow, gorse and blackberry, or is frequented by grazing stock. It is possible that the roots of willow, which form a thick mat submerged at about the depth required for *Isoetes*, may be detrimental. However, it is also possible that build-up of silt due to agricultural practices, may have enhanced riverbed populations. The overall effect of hydro-electric development on the species (excluding *I. muelleri*) is unclear.

### ACKNOWLEDGEMENTS

We thank Drs M.J. Brown, R.J. Chinnock and S.J. Jarman for comments on the manuscript, and Mr M. Neyland for permission to incorporate some of his locality data. Financial support to the first author from the Tasmanian Forest Research Council is gratefully acknowledged.

### REFERENCES

- BROWN, M.J., KIRKPATRICK, J.B. & MOSCAL, A., 1983: *AN ATLAS OF TASMANIA'S ENDEMIC FLORA*. Tasmanian Conservation Trust, Hobart.
- BROWNSEY, P.J. & SMITH-DODSWORTH, J.C., 1989: *NEW ZEALAND FERNS AND ALLIED PLANTS*. David Bateman, Auckland.
- DUNCAN, B.D. & ISAAC, G., 1986: *FERNS AND ALLIED PLANTS OF VICTORIA, TASMANIA AND SOUTH AUSTRALIA*. Melbourne University Press, Carlton, Victoria.
- HALL, J.B., 1971. Observations on *Isoetes* in Ghana. *Bot. J. Linn. Soc.* 64: 117–139.
- HICKEY, R.J., 1990. Studies of neotropical *Isoetes* L. 1. *Euphyllum* a new subgenus. *Ann. Miss. Bot. Gard.* 77: 239–245.
- HICKEY, R.J., TAYLOR, W.C. & LUEBKE, N.T., 1989. The species concept in Pteridophyta with special reference to *Isoetes*. *Am. Fern J.* 79 (2): 78–89.
- JERMY, A.C., 1990. Isoetaceae. In Kramer, K.U. & Green, P.S. (Eds): *THE FAMILIES AND GENERA OF VASCULAR PLANTS, VOL. 1: PTERIDOPHYTES AND GYMNO-SPERMS*. Springer-Verlag, Berlin: 25–31.
- JOHNSON, E.R.L., 1984. Taxonomic revision of *Isoetes* L. in Western Australia. *J. R. Soc. West Aust.* 67: 28–43.
- JONES, D.L. & CLEMESHA, S.C., 1976. *AUSTRALIAN FERNS AND FERN ALLIES*. Reed, Sydney.
- LEACH, G.J. & OSBORNE, P.L., 1985. *FRESHWATER PLANTS OF PAPUA NEW GUINEA*. University of Papua New Guinea Press, Port Moresby.
- MARSDEN, C.R. 1976. Morphological variation and taxonomy of *Isoetes muelleri*. *A. Br. J. Adelaide Bot. Gard.* 1: 37–54.
- MICKEL, J.T., 1979. *HOW TO KNOW THE FERNS AND FERN ALLIES*, Brown, Iowa.
- WAKEFIELD, N.A., 1955. *FERNS OF VICTORIA AND TASMANIA*. Field Naturalist Club of Victoria.

## PRATIA PLATYCALYX IS A SYNONYM OF *P. IRRIGUA* (CAMPANULACEAE: LOBELIOIDEAE)

by D.E. Albrecht

ALBRECHT, D.E., 1992 (31:x): *Pratia platycalyx* is a synonym of *P. irrigua* (Campanulaceae: Lobelioideae). *Pap. Proc. R. Soc. Tasm.* 126: 123–124. ISSN 0080–4703. National Herbarium of Victoria, Birdwood Ave, South Yarra, Victoria, Australia 3141.

*Pratia irrigua* (R. Br.) Benth., hitherto believed to be a restricted Tasmanian endemic, is shown to be conspecific with the extremely variable *P. platycalyx* (F. Muell.) Benth. The name *P. irrigua* is retained, as its basionym predates that of *P. platycalyx*. An amended morphological description is presented.

**Key Words:** Campanulaceae, *Pratia*, South Australia, Victoria, Tasmania.

*Pratia irrigua* (R. Br.) Benth. is currently regarded as a vulnerable Tasmanian endemic (Briggs & Leigh 1988; Kirkpatrick *et al.* 1991). As recently as the early 1970s, it was known only by the type specimen collected by Robert Brown from the islands of the Kent Group. Four contemporary collections of *P. irrigua* are housed at the Tasmanian Herbarium, though in some cases they have been referred somewhat hesitantly to that species (A.M. Buchanan, pers. comm.). Two of these specimens, collected by J. Whinray from Deal and Long Islands, are depicted in Curtis & Stones (1973) and look suspiciously similar to forms of *P. platycalyx* (F. Muell.) Benth., a species found in Victoria, South Australia and Tasmania. A brief study was undertaken to determine whether *P. platycalyx* and *P. irrigua* are distinct species or whether they are simply forms of one variable taxon.

Published taxonomic treatments of *Pratia* (e.g. Bentham 1868, Curtis 1963, Wimmer 1943) separate *P. irrigua* and *P. platycalyx* on the basis of leaf shape and pedicel length; the former have ovate or orbiculate leaves and sessile to subsessile flowers, the latter have linear to obovate leaves and flowers with longer pedicels (at least half as long as the leaves or at least as long as the fruit).

Despite the minimal material and rather poor condition of Brown's type of *Pratia irrigua*, it has been possible to confirm that the specimens have flowers with short pedicels 1–2 mm long and possess some leaves that are orbiculate. However, the leaves are not uniformly orbiculate, nor are they ovate as previously described, but vary in shape from oblanceolate-spathulate to lanceolate. Although most of the leaves on the type are broad, the few intact expanding distal leaves are considerably narrower, suggesting that leaf shape may well be related to stage of growth. The small leaf size and short internodes also give one the impression that the specimens were collected from a stunted, perhaps juvenile (or resprouting) plant.

Examination of herbarium specimens of *P. platycalyx* at the National Herbarium of Victoria (including syntypes) and populations *in situ* has shown it to be an extremely variable species. Most specimens have oblanceolate-elliptic leaves but shape varies from linear to orbiculate. Leaf indumentum and the degree of marginal toothings are similarly variable. As in the type of *P. irrigua*, leaf polymorphism appears to be at least partly related to the stage of growth, as evidenced by the generally broader lower leaves. Environmental conditions also appear to influence leaf size and shape. Plants from more exposed sites subject to higher levels of salinity tend to have shorter  $\pm$  broader leaves. When plants from such sites are transferred to

containers and irrigated with fresh water, subsequent growth has considerably longer, relatively narrower foliage. Pedicel length is similarly variable, ranging from 0.5–20 mm long. However, variation in pedicel length does not appear to be so clearly linked to stage of growth or environmental conditions.

From the level of variation observed in *P. platycalyx*, it is clear that the two characters used to distinguish it from *P. irrigua* are not reliable. Leaf shape and pedicel length in *P. platycalyx* can vary enormously within a population or within an individual plant. Furthermore, as leaf shape and pedicel length vary independently, there is no consistent correlation between short, broad leaves and short pedicels, or conversely, between narrower leaves and long pedicels. As the type of *P. irrigua* is encompassed in the level of variation found in *P. platycalyx*, the two are here regarded as conspecific, the earlier published name *P. irrigua* having priority. A description of the more broadly circumscribed *P. irrigua* is here presented.

***Pratia irrigua*** (R. Br.) Benth., *Fl. Austr.* 4: 132 (1868)

*Lobelia irrigua* R. Br., *Prodr.* 563 (1810)

*Laurentia platycalyx* F. Muell., *Trans. Vict. Inst.* 1: 39 (1855)

*Lobelia platycalyx* (F. Muell.) F. Muell.,

*Fragm.* 4: 183 (1864)

*Pratia platycalyx* (F. Muell.) Benth., *Fl. Austr.* 4: 132 (1868)

Dioecious or gynodioecious perennial *herb.* *Stems* procumbent or decumbent,  $\pm$  zigzagged, glabrous or rarely with scattered, short, spreading hairs, rooting at nodes. *Primary roots* thick and little-branched. *Leaves* distichous; blades rather thick, linear, elliptic, lanceolate, oblanceolate, obovate or orbiculate, 2–40 mm long, 1–8 mm wide, glabrous and lustrous, or occasionally with short fine hairs, particularly on margins; margins entire, or with 1–5 short teeth on either side, each tooth with a minute translucent region towards apex; apex obtuse to subacute, base attenuate, sometimes simulating a petiole. *Flowers* axillary, solitary, borne at irregular intervals along the stem, male, female and hermaphrodite flowers superficially similar. *Pedicels* 0.5–20 mm long, glabrous. *Hypanthium* obconical in male flowers, ellipsoid to ovoid in female and bisexual flowers, sometimes asymmetrical, glabrous. *Calyx* lobes erect or spreading, triangular, 0.4–1.5 mm long, glabrous. *Corolla* subregular, 1.8–4.5 mm long, glabrous; lobes spreading or recurved, subequal, white on both surfaces or mauve-tinged abaxially, acute; tube very short and split to base along the upper side. *Filaments*

attached to the upper edge of the hypanthium, fused just below anther tube, glabrous. *Anther tube* shorter than the corolla, white and sterile in female flowers, blue-black and 1–1.2 mm long in male and bisexual flowers, glabrous, the apex of the two lower anthers each with a seta 0.1–0.3 mm long and a cluster of short hairs c. 0.1 mm long. *Stigma* 2-lobed, densely papillose. *Fruit* ellipsoid to broadly ellipsoid, sometimes asymmetrical, slightly compressed, 5–8 mm long, 3.5–5.5 mm wide, glabrous, indehiscent. *Seeds* light brown, ellipsoid, compressed, 0.7–0.9 mm long, 0.5–0.7 mm wide, testa minutely pitted.

#### Distribution

South Australia, Victoria and Tasmania.

#### Habitat

Occurring on heavy, seasonally damp soils in saltmarsh, wetlands and damp grassland. Ground water varies from fresh to sub-saline.

## REFERENCES

- BENTHAM, G., 1868: *FLORA AUSTRALIENSIS: A DESCRIPTION OF THE PLANTS OF THE AUSTRALIAN TERRITORY*. Vol. 4, Reeve, London: 132.
- BRIGGS, J.D. & LEIGH, J.H., 1988: *RARE OR THREATENED AUSTRALIAN PLANTS*. Special Publication 14. Australian National Parks and Wildlife Service, ACT: 56, 221.
- CURTIS, W.M., 1963: *THE STUDENT'S FLORA OF TASMANIA*. Part 2, Government Printer, Tasmania: 412 pp.
- CURTIS, W.M. & STONES, M., 1973: *THE ENDEMIC FLORA OF TASMANIA*. Part IV, The Ariel Press, London: 278–279.
- KIRKPATRICK, J.B., GILFEDDER, L., DUNCAN, F. & HARRIS, S., 1991: Reservation status and priorities for Tasmanian plants 1. Angiospermae (Dicotyledonae). In Banks, M.R. *et al.* (eds): *ASPECTS OF TASMANIAN BOTANY — A TRIBUTE TO WINIFRED CURTIS*. Royal Society of Tasmania: 163–172.
- WIMMER, F.E., 1943: Campanulaceae-Lobelioideae. *Das Pflanzenreich*. Heft 106: 105–108.

(accepted 7 February, 1992)

## ERRATUM

### SEASONAL CHANGES IN THE HYDROLOGY AND THE DISTRIBUTION OF PLANKTON IN THE BATHURST HARBOUR ESTUARY, 'SOUTHWESTERN TASMANIA, 1988-89

by G.J. Edgar and G.R. Cresswell

(with one text-figure)

EDGAR, G.J. & CRESSWELL, G.R., 1992 (31:x): Seasonal changes in the hydrology and the distribution of plankton in the Bathurst Harbour estuary, southwestern Tasmania, 1988-89. Erratum. Pap. Proc. R. Soc. Tasm. 126: 125. ISSN 0080-4703. Zoology Department, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001 (GJE); CSIRO Division of Oceanography, Marine Laboratories, GPO Box 1538, Hobart, Tasmania, Australia 7001 (GRC).

A figure showing salinity sections within Bathurst Harbour, Tasmania, is reproduced, the wrong figure having been published in 1991.

**Key Words:** Bathurst Harbour, Port Davey, estuary, salinity, Tasmania.

The text-figure reproduced as figure 3 on page 64 (Edgar & Cresswell 1991) was the wrong figure and should be replaced by the figure herewith.

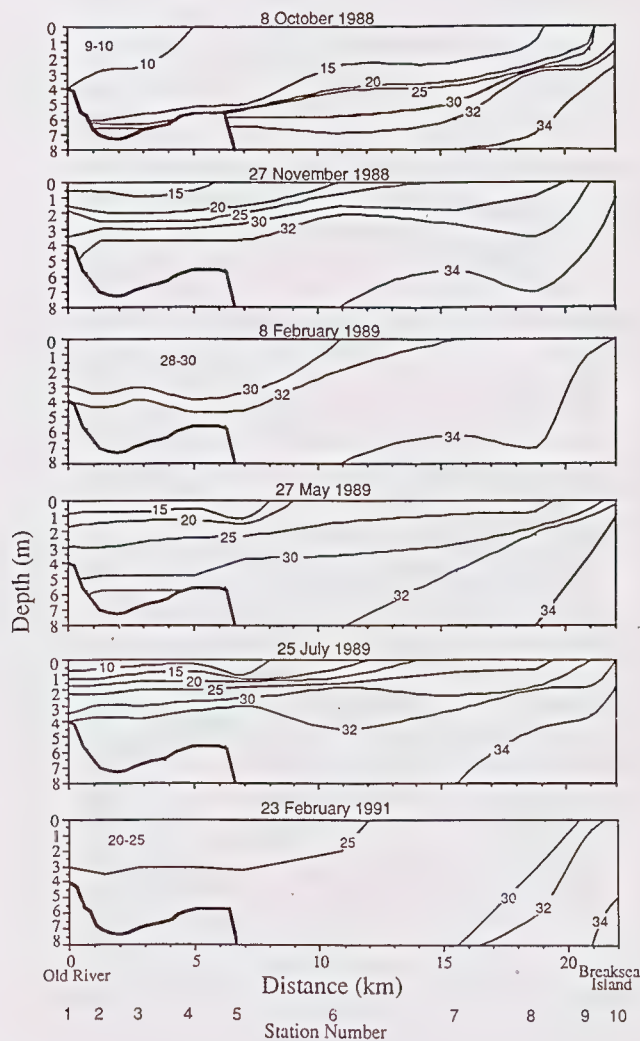


FIG. 3 — Salinity sections from the mouth of the Old River to Breaksea Island as recorded during the various field trips. Bathurst Harbour seabed is shown by bold line.









# PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

## VOLUME 126

### Contents

|                                                                                                                                                                              | <i>page</i> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Annual report                                                                                                                                                                | iv          |
| TIDWELL, W.D. — <i>Millerocaulis richmondii</i> sp. nov., an osmundaceous fern from Mesozoic strata near Little Swanport, Tasmania, Australia                                | 1           |
| RICKARDS, R.B. & BANKS, M.R. — Two <i>Monograptus</i> species from the Prídolí of western Tasmania                                                                           | 9           |
| DIXON, G. — Notes on the geology, geomorphology and soils of the Algonkian Rivulet—upper Maxwell River area, Tasmanian Wilderness World Heritage Area                        | 13          |
| BAILLIE P.W. & SUTHERLAND, F.L. — Devonian lamprophyres from Mt Lyell, western Tasmania                                                                                      | 19          |
| PONDER, W.F. — A new genus and species of aquatic cave-living snail from Tasmania (Mollusca: Gastropoda: Hydrobiidae)                                                        | 23          |
| NEW, T.R. — The lacewings (Insecta, Neuroptera) of Tasmania                                                                                                                  | 29          |
| KIERNAN, K. — Mountain geomorphology and the Last Glaciation at Lake St Clair                                                                                                | 47          |
| JAGO, J.B. & BROWN, A.V. — Early Idamean (Late Cambrian) agnostoid trilobites from the Huskisson River, Tasmania                                                             | 59          |
| HORWITZ, P. & BLAKE, G. — The benthic macrofauna of sludge-affected sediments in the Derwent Estuary, southern Tasmania                                                      | 67          |
| CLARKE, M.J. — A new notospiriferine genus (Spiriferida: Brachiopoda) from the Permian of Tasmania                                                                           | 73          |
| McQUILLAN, P.B. — A checklist of the Tasmanian tortricid moths (Lepidoptera: Tortricidae) and their host-plant relationships                                                 | 77          |
| HAMR, P. — A revision of the Tasmanian freshwater crayfish genus <i>Astacopsis</i> Huxley (Decapoda: Parastacidae)                                                           | 91          |
| RODGERS, K.A. — The laser Raman identity of gibbsite pseudomorphous after crocoite from Dundas, Tasmania                                                                     | 95          |
| HORWITZ, P. & ANDREW, J. — The conservation status of freshwater macro-invertebrates in the Buckland Military Training Area, southeastern Tasmania                           | 101         |
| ANDREWS, A.P. — A descriptive catalogue of the type material (Chordates) in the Tasmanian Museum                                                                             | 109         |
| GARRETT, M. & KANTVILAS, G. — Morphology, ecology and distribution of <i>Isoetes</i> L. in Tasmania                                                                          | 115         |
| ALBRECHT, D.E. — <i>Pratia platycalyx</i> is a synonym of <i>P. irrigua</i> (Campanulaceae: Lobelioideae)                                                                    | 123         |
| EDGAR, G.J. & CRESSWELL, G.R. — Seasonal changes in the hydrology and the distribution of plankton in the Bathurst Harbour estuary, southwestern Tasmania, 1988–89 — erratum | 125         |

#### *Guide for Authors*

A "Guide for Authors" is available on application to the Honorary Editor, Royal Society of Tasmania, GPO Box 1166M, Hobart, Tasmania, Australia 7001.

#### *Acknowledgement*

The Society acknowledges, with thanks, grants towards the cost of publication from the State Government of Tasmania and from the University of Tasmania.

P 506 R 288 T 2